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CONTRIBUTIONS TO PALÆONTOLOGY

I

UPPER CRETACEOUS FLORAS OF THE ROCKY MOUNTAIN REGION

I: STRATIGRAPHY AND PALÆONTOLOGY OF THE FOX HILLS AND LOWER MEDICINE BOW FORMATIONS OF SOUTHERN WYOMING AND NORTHWESTERN COLORADO

By Erling Dorf
Princeton University

With nineteen plates and 8 text figures

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STRATIGRAPHY AND PALAEONTOLOGY OF THE FOX HILLS AND LOWER MEDICINE BOW FORMATION OF SOUTHERN WYOMING AND NORTHWESTERN COLORADO

INTRODUCTION

In view of the controversial nature of the Lance and related floras in connection with Mesozoic-Cenozoic boundary problems, it is rather disconcerting to find that neither the Lance nor the closely related Medicine Bow floras have ever been adequately studied or described. It is the purpose of this paper to outline the stratigraphy and palæontology of the Medicine Bow formation, and to describe and discuss the fossil plants collected from this formation during the past two years. The study of the Lance floras of Wyoming, Montana, and the Dakotas is in progress and will form the basis of subsequent papers. While my interest is primarily in the succession of Upper Cretaceous floras of the West and their relation to succeeding Cenozoic floras, it is hoped that the results of these studies will help to harmonize the conflicting lines of palæontologic and stratigraphic evidence regarding the Mesozoic-Cenozoic boundary in the Rocky Mountain region.

For many years, confusion has arisen from the practice of including all the coal-bearing formations of the Upper Cretaceous and lower Tertiary in the all-embracing "Laramie Group"; as a result, few of the contained floras could be adopted as standards for comparison in other fields. As in all other branches of stratigraphic palæontology, it is necessary first to establish a standard fauna or flora whose age is definitely known from other lines of evidence. Thereafter, the age of other faunas or floras can be determined by comparison and contrast. The Medicine Bow flora is admirably suited to serve as such a standard because its age can be rather definitely determined by its relation to both invertebrate and vertebrate faunas of known age.

The study of the Medicine Bow flora is part of a program on Upper Cretaceous floras of the Rocky Mountain region which I have undertaken under the joint auspices of the Carnegie Institution of Washington and Princeton University. The distribution of the 6 localities from which the fossil plants were obtained is indicated in figure 1. At each of these localities the sections were carefully measured by compass-traverses, and the exact stratigraphic position of each plant-bearing horizon was determined with reference to a well-established and diagnostic faunal zone of the underlying Fox Hills formation. Sections were measured by A. P. Conway, Dean Hill, and M. L. Rittenhouse, students at Princeton University, who also identified most of the invertebrates collected. The invertebrate identifications were checked by Dr. John B. Reeside of the U. S. Geological Survey. Friendly encouragement and constructive criticism have been freely given by Dr. Ralph W. Chaney of the University of California. Valuable suggestions in various phases of the study have been made by Dr. Roland W. Brown of the U. S. Geological Survey, and Dr. S. H. Knight of the University of Wyoming. Herbarium material has been

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generously loaned by the New York Botanical Garden. Competent field assistance was rendered by Beverly Wilder of Antioch College, H. H. Sharkey of Princeton University, and Ruth K. Dorf.

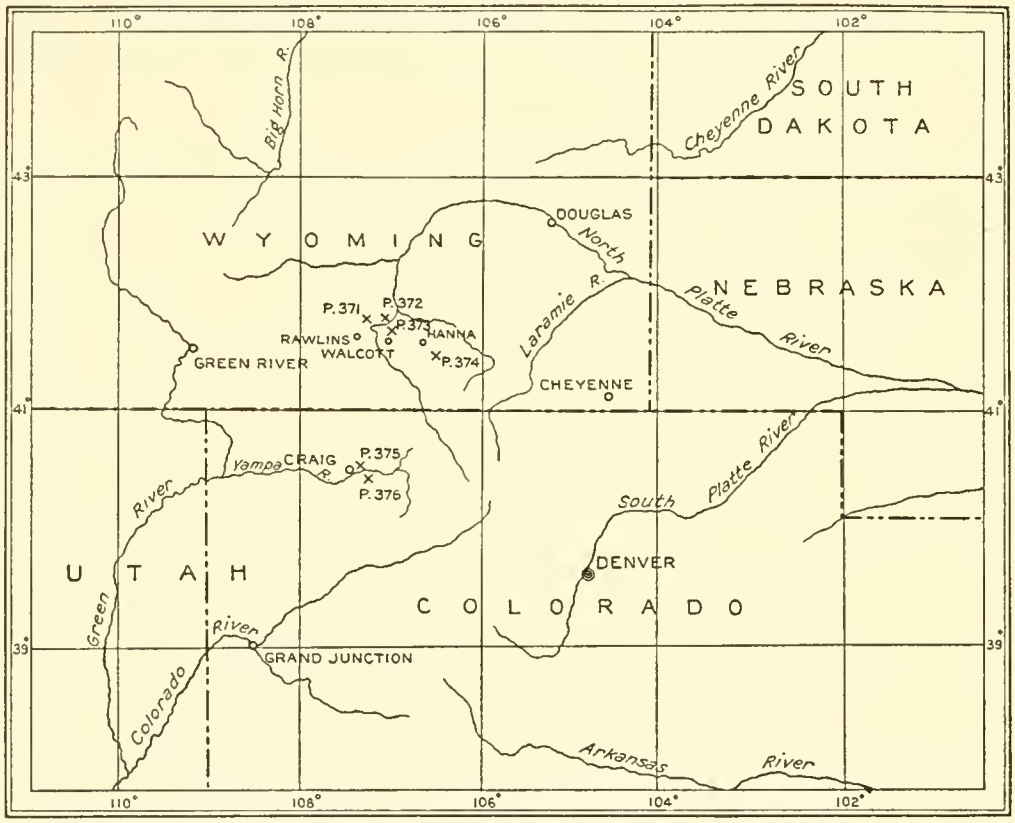

FIG. 1—Index map, showing location of Localities P. 371 to P. 376.

PRESENT PHYSICAL CONDITIONS AND VEGETATION

Of the 6 localities studied, 4 are situated in southern Wyoming and the remaining 2 in northwestern Colorado, as shown in figure 1. Both areas are essentially alike in physical and climatic conditions and differ only in details with respect to the type and distribution of vegetation.

These areas are included in the high, barren intermontane basins of the Rocky Mountain system. Their average elevation ranges from approximately 5000 to 7000 feet. The topography is sub-maturely dissected, and largely controlled by the differential erosion of variously dipping strata of unequal hardness. The southern Wyoming region lies in the drainage area of the North Platte and Medicine Bow rivers, which are the only permanent streams. The Yampa River drains the area in northwestern Colorado. The narrow flood plains of these streams are features of primary importance in the distribution of modern vegetation.

On the basis of moisture and temperature conditions these areas are near the eastern edge of the cool, arid climatic province.[1] Normal annual precipitation

[1] Livingston and Shreve, Carnegie Inst. Wash. Pub. No. 284, 380, 1921.

averages between 10 and 15 inches, little of which falls during the growing season, which usually lasts from 80 to 110 days in the summer months, June to September. The mean annual temperature is rather low, averaging from 40 to 45° F. During the short growing season, however, temperatures of over 100° F. are not unusual. Köppen and Geiger [1] place the areas in the Dry, Cold, Steppe climate, BSKW.

Ecologically, the vegetation in the areas of both southern Wyoming and northwestern Colorado may be divided into two distinct units: the sagebrush-grassland association of the dry ridges and divides, and the poplar-willow association of the moist, narrow flood plains of the permanent streams. In the following list of common species, those present in southern Wyoming, but not in northwestern Colorado, are marked with an asterisk (*); those in northwestern Colorado, but not southern Wyoming, with a dagger (†); the unmarked species are prevalent in both areas.[2]

Ridges and Divides (Sagebrush-Grassland Association):

Trees and shrubs—

Artemisia tridentata Nuttall—Black sagebrush
Atriplex nuttallii S. Watson—Salt sage
Chrysothamnus graveolens (Nuttall) Greene—Rabbit brush
Eurotia lanata (Pursh) Moquin—White sage or Winter fat
Grayia spinosa (Hooker) Moquin—Hop sage
Juniperus spp.—Cedars
Kunzia tridentata (Pursh) Sprengel
† Pinus edulis Engelmann—Pinyon pine
Sarcobatus vermiculatus (Hooker) Torrey—Greasewood

Herbs—

Agropyron spicatum (Pursh) Scribner and Smith—Wheat grass
Bouteloua oligostachya Torrey—Short grass
Bulbilis dactyloides Rafinesque-Schmaltz—Buffalo grass
Elymus sp.?—Rye grass
Opuntia spp.—Prickly pears

Stream Flood Plains (Poplar-Willow Association):

Trees and shrubs—

Amelanchier alnifolia Nuttall—Service berry
Cercocarpus ledifolius Nuttall—Mountain mahogany
† Cratægus rivularis Nuttall—Black haw
Populus angustifolia James—Narrow-leaved cottonwood
* Populus sargentii Dode—Broad-leaved cottonwood
* Ribes longiflorum Nuttall—Flowering currant
Ribes spp.—Gooseberry
Rosa sp.?—Wild rose
† Salix amygdaloides Anderson—Willow
Salix longifolia Mühlenberg—Willow
Shepherdia argentea Nuttall—Buffalo berry
† Symphoricarpus oreophilus Gray—Waxberry

[1] Köppen and Geiger, Klimakarte der Erde (Gotha, Justus Perthes), 1928.
[2] Detailed observations on distribution are given in Cary, M., N. A. Fauna, vol. 33, 1911, and vol. 42, 1917.

STRATIGRAPHY

SOUTHERN WYOMING

The Medicine Bow formation is an alternating succession of shales, sandstones, and coal beds resting conformably on the Lewis shale in the Hanna and Carbon basins of south central Wyoming. The first comprehensive report on this region was by Veatch,[1] who designated the formation as "Lower Laramie" on the basis of stratigraphic position and "the absence of marine fossils." For essentially the same beds Bowen [2] subsequently proposed the name Medicine Bow formation, which has since become generally accepted. Regarding the fossils found in the formation, Bowen wrote as follows:

> "The formation contains remains of fresh and brackish water invertebrates, land plants, and bones of vertebrates. The plants are regarded by F. H. Knowlton as of the same age as the plants of the Laramie of the Denver Basin. The invertebrates are considered by T. W. Stanton to belong to the fauna of the Lance formation. The bones belong in part to the ceratopsians, but no specimens have been found that are sufficiently diagnostic for even generic determination."

In a later report on the same general region, Dobbin, Bowen, and Hoots [3] described the formation in more detail and included within its lower limits the "sandstone beds with a marine fauna of Fox Hills type." It is clearly evident from both Veatch's and Bowen's statements as quoted above that this marine sandstone had previously been excluded from the Medicine Bow formation and regarded as the upper portion of the Lewis shale. The various interpretations of the late Cretaceous and early Tertiary deposits of the region are shown in figure 2, which is compiled from the three reports cited.

The writer's interpretation of the section is presented in the right-hand column of figure 2. The recognition of the Fox Hills formation between the Lewis and the Medicine Bow is based upon the occurrence of the *Sphenodiscus* zone, which is of restricted Fox Hills age,[4] at numerous localities in the region, and upon the marked changes in the aggregate lithology of the sequence. Veatch apparently collected no fossils from these beds, nor did he mention any changes in lithology in the upper portion of the Lewis formation or the lower portion of the "Lower Laramie." Bowen[5] reported the presence of a persistent gray sandstone near the top of the Lewis shale, but did not mention the massive, coarse, concretionary sandstones near the base of the Medicine Bow formation. He apparently collected no fossils from these units at that time. The subsequent report by Dobbin, Bowen, and Hoots recorded characteristic Fox Hills species including *Sphenodiscus lenticularis* (Owen) Meek near the top of their Lewis formation, and "a few marine beds with invertebrate fossils of Fox Hills types intercalated in the basal part" of the Medicine Bow formation.[6] Although they did not recognize the Fox Hills formation as a

[1] Veatch, A. C., *Coal Fields of East-central Carbon County, Wyoming*, U. S. Geol. Survey Bull. 316, 244–260, 1907.
[2] Bowen, C. F., *Stratigraphy of the Hanna Basin, Wyoming*, U. S. Geol. Survey Prof. Paper 108-L, 227–235, 1918.
[3] Dobbin, C. E., Bowen, C. F., and Hoots, H. W., *Geology and Coal and Oil Resources of the Hanna and Carbon Basins, Carbon County, Wyoming*, U. S. Geol. Survey Bull. 804, 9, 23, 1929.
[4] Reeside, J. B., Jr., written communication, May 9, 1935.
[5] Bowen, C. F., op. cit., 228, 229.
[6] Dobbin, C. E., Bowen, C. F., and Hoots, H. W., op. cit., 21, 22.

unit in either the text or the maps, these authors suggested its presence, as shown in the following quotation:[1]

"The Fox Hills sandstone of eastern Wyoming is almost certainly represented in the uppermost part of the Lewis shale, [and] in the lower 500 feet of the Medicine Bow formation. . . ."

Veatch, 1907				Bowen, 1918		
System	Group	Formation	Thickness (feet)	System	Formation	Thickness (feet)
Tertiary		North Park	4,500		North Park	0–400±
		—*Unconformity*—			—*Unconformity*—	
		Fort Union	1,200±	Tertiary	Hanna	7,000±
	Laramie hitherto so-called	"Upper Laramie"	6,800±		—*Unconformity*—	
		—*Unconformity*—		Tertiary?	Ferris	6,500±
Cretaceous		"Lower Laramie"	6,500		Medicine Bow	6,200±
	Montana	Lewis	1,800–3,000	Cretaceous	Lewis	3,300±
		Mesaverde	1,500–3,200		Mesaverde	2,700

Dobbin, Bowen, and Hoots, 1929			Present Interpretation		
Age	Formation	Thickness (feet)	System	Formation	Thickness (feet)
Miocene?	North Park	0–400*	Miocene?	North Park	0–400*
	—*Unconformity*—			—*Unconformity*—	
Eocene	Hanna	7,000*	Eocene	Hanna	7,000*
	—*Unconformity*—		Paleocene	—*Unconformity*—	
	Ferris	6,500*		Ferris	6,500*
Eocene?	Medicine Bow	4,000–6,200*		Medicine Bow	4,000–6,000*
Upper Cretaceous			Upper Cretaceous	Fox Hills	375–400
	Lewis	3,300*		Lewis	3,000*
	Mesaverde	2,200–2,700*		Mesaverde	2,200–2,700*

* Approximate.

FIG. 2—Late Cretaceous and early Tertiary formations in the Hanna Basin, Wyoming.

Since this report Dobbin and Reeside have described several sections in this region in which they encountered distinctive faunas of the Fox Hills type in the transition beds between the marine Lewis shale and the non-marine Medicine Bow formation.[2] The Fox Hills invertebrates, including the diagnostic *Sphenodiscus*

[1] Dobbin, C. E., Bowen, C. F., and Hoots, H. W., ibid., 23.

[2] Dobbin, C. E., and Reeside, John B., Jr., *The Contact of the Fox Hills and Lance Formations*, U. S. Geol. Survey Prof. Paper 158-B, 21, 22, 1929.

lenticularis, were shown to come from strata included within the basal part of the Medicine Bow formation and not from the sandstones within the upper part of the Lewis shale. The writer's field studies and collections, which are later described in detail, are in agreement with these observations. It is clearly evident, therefore, that sediments of Fox Hills age form a part of what has hitherto been regarded as the basal portion of the Medicine Bow formation. The recognition of the Fox Hills formation in the region must then depend on whether or not it can be distinguished as a separable lithologic unit. The following criteria for the recognition and delimitation of this formation in northeastern Colorado have recently been published by a committee of the Rocky Mountain Association of Petroleum Geologists [1] after a field conference with Dr. J. B. Reeside, Jr.:

"The base of the Fox Hills formation shall be considered as the horizon below which the section is predominantly gray marine clay shales and sandy shales of Pierre age, and above which the section changes rapidly to a buff to brown sandstone containing numerous large gray to brown, hard, sandy concretions. This lower concretionary member is commonly overlain by a series of light gray to brown sandstones and sandy shales.

"The top of the Fox Hills formation shall be considered as the horizon above which the section is composed predominantly of fresh and brackish-water deposits accompanied by coals and lignitic shales, and below which it is predominantly marine."

The application of these criteria to the basal 400± feet of the Medicine Bow formation has recently been made by Conway in an unpublished report.[2] He has pointed out that all of the above requirements are exactly fulfilled in the sections which he studied near Corson Ranch, near Walcott, and near Rawlins in this area. It is interesting to note that the lowest coal beds in the sections are invariably at the horizon which separates the underlying marine faunas from the overlying fresh and brackish-water faunas, and which also separates the massive, more persistent sandstones below from the thinner, lenticular sandstones above. For practical purposes of mapping, therefore, the lowest coal beds can be regarded as the base of the Medicine Bow formation.

The horizons which have yielded plant remains all lie within the basal 1300 feet of the Medicine Bow formation, as here redefined. Each horizon has been accurately located with reference to the characteristic Fox Hills fauna, of which the ammonite *Sphenodiscus lenticularis* is regarded as the most trustworthy and diagnostic index species. It is certain, therefore, that the evidence from stratigraphic position and from marine invertebrates indicates post-Fox Hills age for the plant-bearing horizons. Their pre-Fort Union age is equally clearly indicated by the presence of ceratopsian dinosaurs and invertebrates of Lance age in the Medicine Bow formation, and *Triceratops* dinosaurs in the basal beds of the overlying Ferris formation.[3] The combined geologic data, exclusive of the plant evidence, are, therefore, consistent throughout in supporting a reference of the Medicine Bow formation as of Lance age, or more specifically as of Hell Creek age. The

[1] Lovering, T. S., Aurand, H. A., Lavington, C. S., and Wilson, J. H., *Fox Hills Formation, Northeastern Colorado*, Amer. Assoc. Petroleum Geologists Bull., vol. 16, 702, 1932.

[2] Conway, W. P., Jr., *Stratigraphy and Paleontology of the Medicine Bow Formation, Hanna Basin, Wyoming*, Dept. Geology, Princeton University, senior thesis, 30–32, 1936.

[3] Dobbin, C. E., Bowen, C. F., and Hoots, H. W., U. S. Geol. Survey Bull. 804, 25, 1929.

Lance age of the Medicine Bow formation has previously been discussed by Hares [1] and substantiated by Dobbin and Reeside.[2]

NORTHWESTERN COLORADO

The plant remains from this region were obtained from the succession of sandstones, shales, and coal beds occupying the same stratigraphic position above the Lewis shale as do the sediments of the Medicine Bow formation in southern Wyoming. These sediments have hitherto been referred to the Laramie or "Laramie" formation. In view of their closer geographic position to the type locality of the Medicine Bow formation than to that of the Laramie formation, as now restricted, it seems more appropriate to refer them to the former formation. Such a reference is further substantiated by the fact that the outcrop of these strata can be traced with only slight breaks almost continuously from the area in northwestern Colorado to the western part of the Hanna basin in southern Wyoming.

Attention in this region was centered about the area surrounding Craig, Colorado, because of the previous reports of plant fossils in this region and because of their occurrence in sediments conformably overlying beds which have yielded a Fox Hills fauna, including the index ammonite *Sphenodiscus* [3] which has been used throughout my work as a reference zone.

The first important contribution to the geology of this region was the report on the Yampa coal field by Fenneman and Gale.[4] The sediments conformably overlying the Lewis shale were here referred to the Laramie formation on the basis of stratigraphic position. A more comprehensive report by Gale on the coal fields of northwestern Colorado and northeastern Utah was published in 1910.[5] The name Laramie formation was still retained for the strata above the Lewis shale on the basis of a few species of invertebrates and plants. In 1925, Hancock, [6] who was followed by Sears,[7] expressed doubt regarding the reference of these same beds to the Laramie formation by placing the name in quotation marks. Additional marine invertebrates, including the index species *Sphenodiscus lenticularis* (?), were obtained by Hancock from the lower massive sandstones of his "Laramie" formation, indicating the Fox Hills age of these beds. In the sections which we measured a few miles west of Craig, additional Fox Hills species were collected from the massive sandstones above the Lewis shale. The same criteria for the recognition of the Fox Hills formation as were applied in southern Wyoming (see p. 6) were found to obtain in this region.

All of the plant remains secured from this region were collected from horizons in the lower Medicine Bow formation, lying within a few hundred feet above the massive sandstones here referred to the Fox Hills formation. No attempt was made to determine the upper limit of the Medicine Bow formation, although it clearly

[1] Hares, C. J., Washington Acad. Sci. Jour., vol. 5, 328–330, 1915.
[2] Dobbin, C. E., and Reeside, J. B., Jr., U. S. Geol. Survey Prof. Paper 158-B, 23, 1929.
[3] Hancock, E. T., U. S. Geol. Survey Bull. 757, 22, 1925; Dobbin, C. E., and Reeside, J. B., Jr., op. cit., 23.
[4] Fenneman, N. M., and Gale, H. S., U. S. Geol. Survey Bull. 297, 1906.
[5] Gale, H. S., U. S. Geol. Survey Bull. 415, 1910.
[6] Hancock, E. T., op. cit., 21.
[7] Sears, J. D., U. S. Geol. Survey Bull. 751, 269–326, 1925.

includes all but the basal 475 feet of what has hitherto been termed the "Laramie" formation. The "Laramie" has previously been separated by a persistent conglomerate from the overlying Post-"Laramie" (Fort Union?) formation. The validity of the Post-"Laramie" formation as a separate lithologic unit has as yet not been fully corroborated by fossil evidence.

The changes in the interpretation of the stratigraphic sequence in this region are shown in Figure 3. The formations below the Mesaverde group and above the Wasatch formation have been omitted as irrelevant to the present problem.

Fenneman and Gale, 1907			Gale, 1910		
Series	Formation	Thickness (feet)	System	Formation	Thickness (feet)
Eocene?	(not designated)	—	Tertiary	Wasatch	3400
Cretaceous	Laramie	900+		Post-Laramie (Fort Union?)	800+
				—Unconformity—	
			Cretaceous	Laramie	1200
	Lewis	1200+		Lewis	1200+
	Mesaverde	3500+		Mesaverde	5280+

Sears, 1925; Hancock, 1925 *				Present Interpretation			
Series	Group	Formation	Thickness (feet)	Series	Group	Formation	Thickness (feet)
Eocene		Wasatch	3000–5600	Eocene		Wasatch	Not Determined
		-Unconformity-				-Unconformity-	
Eocene?		Post-"Laramie"	0–800	Paleocene?		Post-"Laramie"	Not Determined
		-Unconformity-				-Unconformity?	
Upper Cretaceous		"Laramie"	1020–2350?	Upper Cretaceous		Medicine Bow	1200+
						Fox Hills	475+
		Lewis	900–1600			Lewis	1600
	Mesaverde	Williams Fork	1600–3400		Mesaverde	Williams Fork	1600
		Iles	1350			Iles	1350

* Hancock's section did not include the Post-"Laramie" and Wasatch formations.

FIG. 3—Late Cretaceous and early Tertiary formations in northwestern Colorado.

LOCAL SECTIONS AND MAPS

Corson Ranch, Wyoming, Localities P. 371 and P. 372

Along the North Platte River in sections 2 and 3, T. 22 N., R. 85 W., the valley wall exposes a section from the upper part of the Lewis shale through the Fox Hills formation and into the Medicine Bow formation. The leaf horizons in the Medicine Bow formation are located about a half mile north of the line of the section, as follows:

Locality P. 371: SE. $\frac{1}{4}$ sec. 34, T. 23 N., R. 85 W., 275 yards N. 75° W. of the southeast section corner of sec. 34.

Locality P. 372: SW. $\frac{1}{4}$ sec. 35, T. 23 N., R. 85 W., 260 yards N. 53° W. of the half-mile marker of the lower side of sec. 35.

The exact positions of these localities and the areal distribution of formations in the region are shown in figure 4. The measured section, indicating lithology,

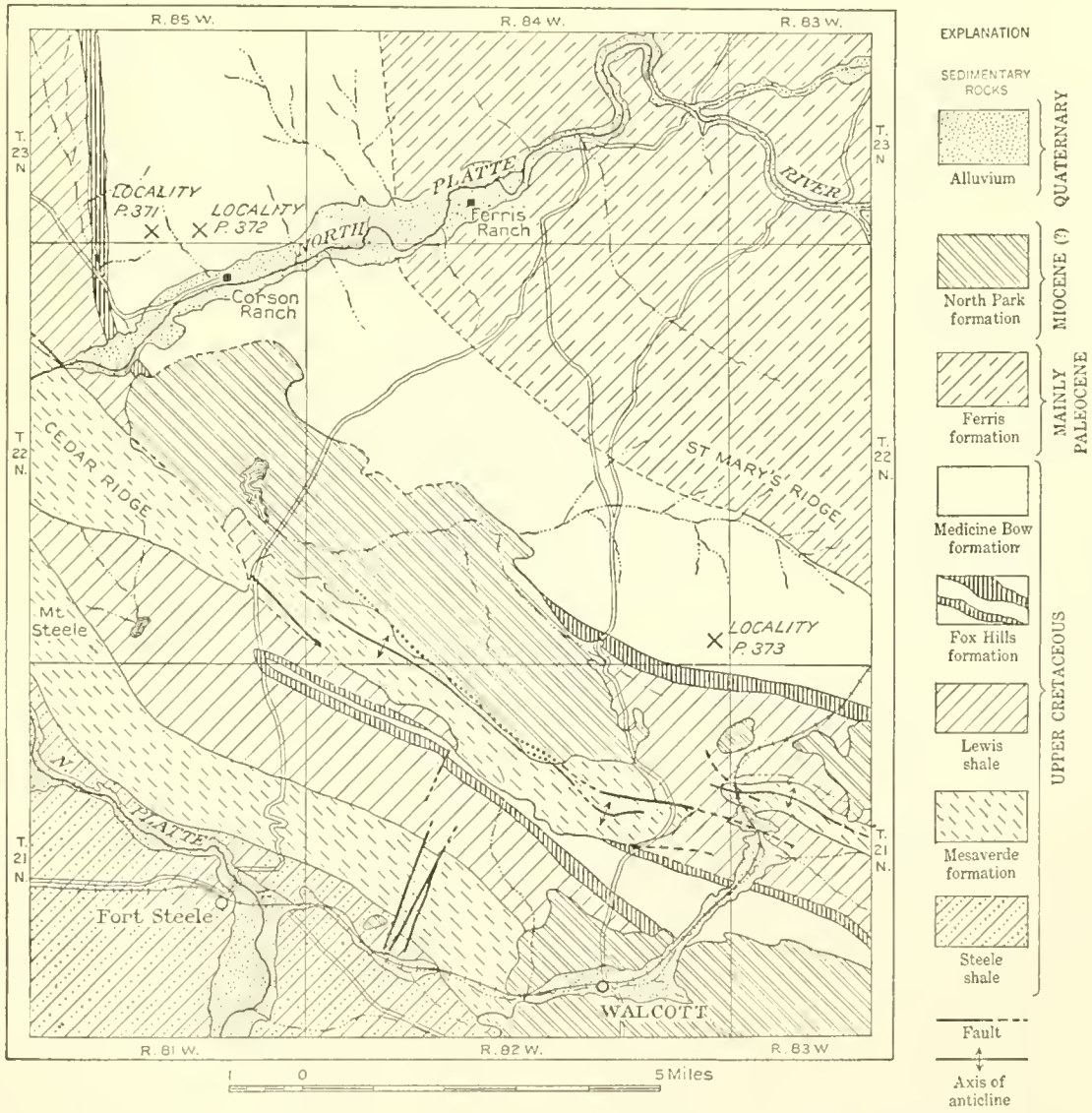

Fig. 4—Geological setting of Localities P. 371, P. 372, and P. 373. After U. S. Geological Survey Bull. 804, pl. 27.

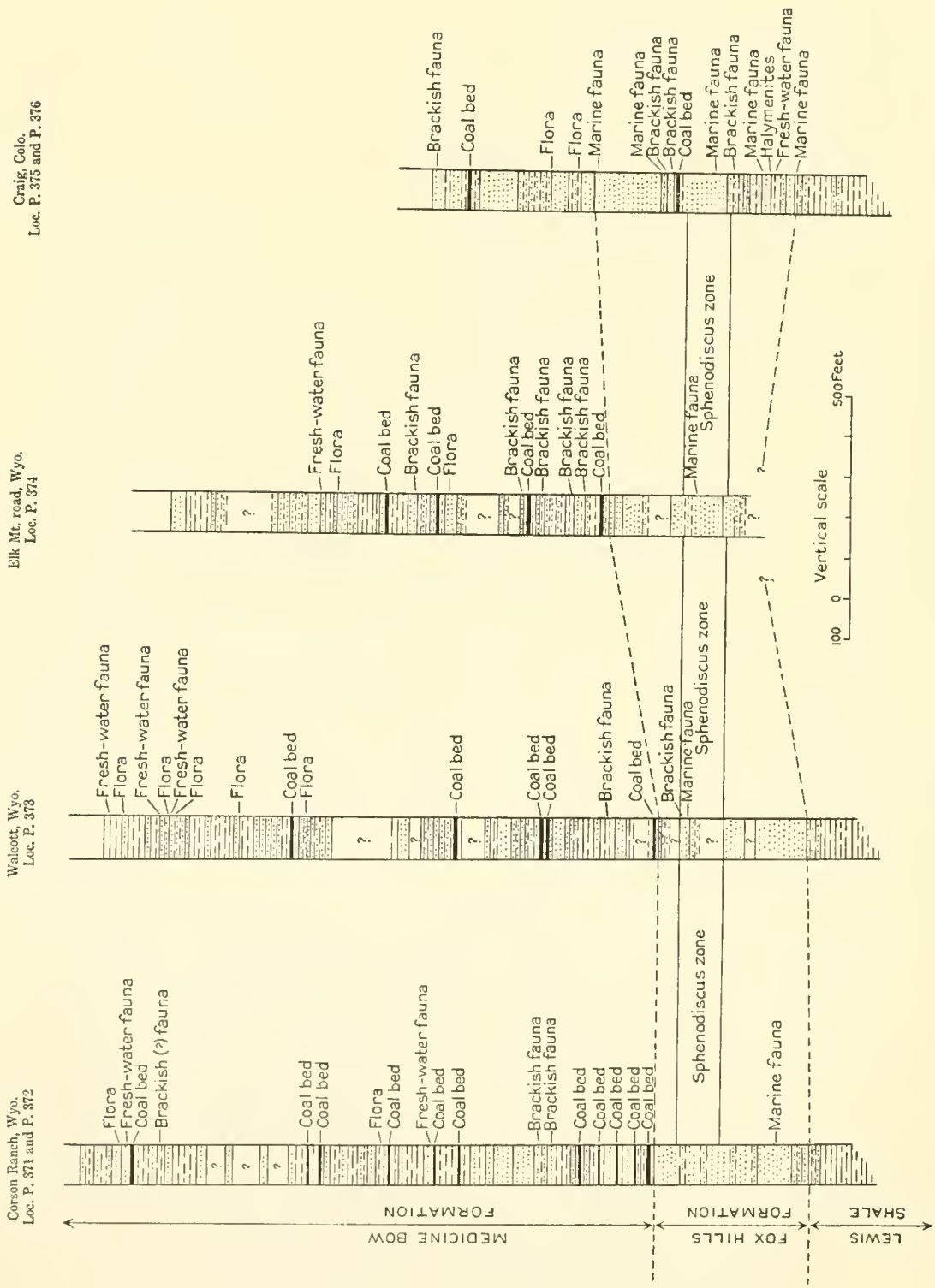

FIG. 5—Measured sections showing positions of faunas, floras, and coal beds.

thickness, and the position of faunal and floral horizons, as shown in figure 5, is as follows:

Section in the Lewis, Fox Hills, and Medicine Bow formations in secs. 2 and 3, T. 22 N., R. 85 W., Wyoming[1]

	Thickness in feet
Medicine Bow formation (lower part):	
Sandstone, gray, soft, massive, with concretionary lenses alternating with lignitic shales. Hard, yellowish 4-foot layers of sandstone near middle and top....	73
Sandstone, gray, hard, thinly bedded, weathering to light brown. Hard gray bed near base yielded the following species of fossil plants (Locality P. 372):	
Bracts (?)	
Canna cf C.? magnifolia	
Carpites glumæformis	
Celastrus taurinensis	
Cinnamomum affine	
Cissites lobatus	
Cyperacites sp.	
Dombeyopsis obtusa	
Dombeyopsis trivialis	
Dryophyllum subfalcatum	
Equisetum sp.	
Ficus cockerelli	
Ficus crossii	
Ficus planicostata	
Ficus trinervis	
Grewiopsis saportana	
Leguminosites arachioides minor	
Magnoliophyllum cordatum	
Myrica torreyi	
Palmocarpon? subcylindricum	
Pandanites corsoni	
Phyllites colubrinoides	
Phyllites sp.	
Pistacia eriensis	
Quercus viburnifolia	
Rhamnus cleburni	
Rhamnus salicifolius	
Sabalites eocenica	
Sabalites montana	
Sequoia? acuminata	
Trochodendroides nebrascensis	
Typha sp.	
Viburnum marginatum	
Viburnum montanum	
Zingiberites dubius	
Zizyphus hendersoni	
This same bed contained the fresh-water molluscs:	
Unio danai Meek and Hayden	
Goniobasis tenuicarinata Meek and Hayden....	20
Sandstone, grayish-white, soft, massive; basal beds with the fresh-water molluscs:	
Campeloma nebrascensis nebrascensis Meek and Hayden	
Goniobasis tenuicarinata Meek and Hayden	
Proparreysia holmesiana White	
Tulotoma thompsoni White	
Unio baueri Stanton	
U. priscus Meek and Hayden n. var.?....	28
Coal bed....	2
Shale, gray, soft, intercalated with thin lignitic shales and massive to cross-bedded soft, gray sandstones. Horizon 30 feet from base yielded petrified wood and a single brackish-water mollusc:	
Corbula subtrigonalis perundata Meek and Hayden?....	80
Sandstone, soft, gray, cross-bedded, massive....	20
Shale, gray to brown, sandy, and soft, gray massive sandstone....	85
Shale, gray and yellowish-brown with a few thin, massive, soft, gray sandstones chiefly covered in valley....	198
Shale, gray to brown, with 2 thin lignite layers and thin brecciated yellow sandstone layers at top....	91
Sandstone, grayish-white, hard, massive....	12
Shale, gray to brown, with intercalated thin lignitic shales and massive gray sandstones....	91
Sandstone, gray, hard, massive with thin brecciated bed at base....	20
Shale, gray to brown, gypsiferous, with a few thin, hard gray sandstone lenses. One of these lenses, 15 feet from top, yielded the following species of fossil plants (Locality P. 371):	

[1] Nomenclature of invertebrate genera and species follows Henderson, J., Geol. Soc. Am., Spec. Pap. No. 3, 1935.

Aneimia sp.
Asplenium? coloradense
Celastrus taurinensis
Cyperacites sp.
Dryophyllum subfalcatum
Dryopteris? carbonensis
Equisetum sp.
Ficus cockerelli
Ficus planicostata
Ficus tesselata
Ficus trinervis
?Juglans prærugosa
?Magnolia dakotana
Magnolia pulchra
Magnoliophyllum cordatum
Phyllites colubrinoides
Phyllites conwayi
Pistacia eriensis
Rhamnus salicifolius
Sabalites eocenica 54

Shale, gray, soft, yellowish-brown, gypsiferous, with massive, soft, gray sandstone lenses and three 1-foot coal beds. Horizon near middle with shells of the fresh-water mollusc:
Unio danai Meek and Hayden 216

Sandstone, hard, gray, massive, concretionary at top 20

Sandstone, gray, soft, nodular, with 4- to 6-inch gray shale layers 96

Sandstone, yellowish-brown, hard, and intercalated brown and gray shales; few thin carbonaceous layers. Horizon near middle with shells of brackish-water mollusc:
Ostrea glabra glabra Meek and Hayden 30

Shale, gray to yellowish-brown, with massive, gray sandstone and concretionary gray sandstone at top, containing shells of the brackish-water mollusc:
Ostrea sp. 66

Sandstone, gray, massive, lenticular and concretionary near top 12

Shale, yellowish and gray, with 3-foot coal bed in middle 15

Sandstone, gray, massive, and concretionary 17

Shale, yellowish-brown, with intercalated layers of gray shale, thin lenses of brownish hard sandstone, and 3 thin coal beds 128

Shale, gray, sandy 15

Coal bed 3

Fox Hills formation:

Sandstones, gray, concretionary, intercalated with gray, sandy shales 267

Sandstone, grayish-white, massive, with intercalated 6-inch layers of gray shale. Horizon near middle contains numerous shells of the following marine molluscs:
Baculites sp.
Cardium whitei Dall
Corbula subtrigonalis perundata Meek and Hayden
C. subtrigonalis subtrigonalis Meek and Hayden
Corbula sp.
Dentalium sp.
Discoscaphites sp.
Gervillia recta Meek and Hayden
Melania insculpta Meek
M. wyomingensis Meek
Pteria (Pseudoptera) fibrosa Meek and Hayden
Tancredia americana Meek and Hayden
Tellina equilateralis Meek and Hayden
Yoldia scitula Meek and Hayden 83

Shale, grayish-white, sandy 20

Sandstone, gray, hard, concretionary 15

Total Fox Hills formation 385

Lewis shale:

Shale, grayish-white, sandy near top, grading down into darker gray shales. Thickness not measured.

Five Miles North of Walcott, Wyoming, Locality P. 373

In this region a fairly continuous section from the Lewis shale through the Fox Hills formation and into the Medicine Bow formation is exposed about a mile

east of the Walcott-Ferris ranch road, 5 miles N. 15° E. of the town of Walcott. Collections of both invertebrates and plants were secured from several horizons. The exact position of Locality P. 373, from which the plant remains were obtained, is in the SE. ¼ sec. 36, T. 22 N., R. 84 W., shown in figure 4. The details of the measured section and the position of faunal and floral horizons (figure 5) are as follows:

Section in the Lewis, Fox Hills, and Medicine Bow formations in sec. 1, T. 21 N., R. 84 W., and sec. 36, T. 22 N., R. 84 W., Wyoming

	Thickness in feet
Medicine Bow formation (lower part):	
Shale, gray, with thinly bedded, gray sandstone lenses 2–5 feet thick at irregular intervals. Horizon 20 feet from top contains fresh-water molluscs:	
Corbicula sp.	
Goniobasis tenuicarinata Meek and Hayden	
Horizon 29 feet from top yielded the following species of fossil plants:	
Carpites walcotti; Cinnamomum affine; Cyperacites sp.; Dombeyopsis trivialis; Ficus planicostata; Leguminosites arachioides minor; Myrica torreyi; Pistacia eriensis; Rhamnus salicifolius; Sabalites eocenica; Trochodendroides nebrascensis; Viburnum marginatum; Zizyphus hendersoni	135
Shale, gray to brownish, sandy, with occasional thin irregular lenses of concretionary grayish-brown sandstones. Fresh-water molluscs at top:	
Campeloma nebrascensis nebrascensis Meek and Hayden	
Tulotoma thompsoni White	
Unio sp.	
Leaf horizon at base:	
Carpites walcotti; Celastrus taurinensis; Dryophyllum subfalcatum; Ficus planicostata; Magnoliophyllum cordatum; Myrica torreyi; Pistacia eriensis; Rhamnus cleburni; Rhamnus salicifolius; Trochodendroides nebrascensis; Viburnum marginatum	20
Shale, gray, sandy, with few thin lignitic shale beds and intercalated thin gray sandstones. Fresh-water molluscs one foot from top:	
Campeloma nebrascensis nebrascensis Meek and Hayden	
Unio priscus abbreviatus Stanton and Hatcher	
U. priscus n. var.?	
Fossil leaves at horizon 20 feet from top:	
Carpites walcotti; Celastrus taurinensis; Cinnamomum affine; Dombeyopsis trivialis; Ficus planicostata; Magnoliophyllum cordatum; Myrica torreyi; Palæoaster inquirenda; Pisonia? racemosa; Pistacia eriensis; Quercus viburnifolia; Rhamnus cleburni; Rhamnus salicifolius; Sabalites eocenica; Trochodendroides nebrascensis; Viburnum marginatum	51
Shale, gray to brown, intercalated with thin lenses of concretionary sandstone, two lignitic shale beds near base	65

Shale, gray, and thinly bedded gray sandstone. Following species of plants collected at base:

Carpites glumæformis	Magnoliophyllum cordatum
Carpites walcotti	Myrica torreyi
Dombeyopsis trivialis	Pistacia eriensis
Dryophyllum subfalcatum	Quercus viburnifolia
Ficus cockerelli	Rhamnus cleburni
Ficus planicostata	Rhamnus salicifolius
Grewiopsis saportana	Sequoia? acuminata
Juglans leconteana	Viburnum marginatum
Magnolia dakotana	Zizyphus hendersoni 61

Shale, dark gray, carbonaceous, thin lignites and gray massive to regularly bedded sandstone near base 48

Shale, gray to brown, sandy, with massive ripple-marked and concretionary gray sandstone at top 77

Shale, gray, sandy, grading upward into thinly bedded, gray sandstone and single coal bed at top. Fossil leaves at base:

Cinnamomum linifolium	Rhamnus cleburni
Ficus planicostata	Rhamnus salicifolius
Myrica torreyi	Trochodendroides nebrascensis 38

Sandstone, gray, regularly thinly bedded 6

Shale, gray, sandy, with few exposed thin beds of gray, concretionary sandstones; lignite float; mostly covered 216

Sandstone, grayish-brown, concretionary, with few intercalated shale beds 31

Shale, soft; mostly covered 30

Shale, gray, sandy, and intercalated, thin to massively bedded gray sandstones, 2-foot coal bed near base 97

Covered in valley, probably shale 60

Sandstone, gray, persistent bed, somewhat concretionary 11

Shale, dark gray, carbonaceous 18

Sandstone, gray, thinly bedded 35

Shale, gray to brownish-gray, sandy 20

Sandstone, gray, soft, thinly bedded 10

Shale, gray to brownish-gray, sandy 40

Coal bed 4

Shale, dark gray, soft 10

Coal bed 2

Sandstone, gray, massive 10

Sandstone, gray, soft, thinly bedded, with concretionary lens near middle. Fragments of brackish-water mollusc:

Ostrea sp. 38

Sandstone, gray, hard, lenticular, concretionary 6

Shale, gray to brownish-gray, sandy, with few thinly bedded, soft gray sandstone layers and intercalated lenses of gray, concretionary sandstones 88

Shale, dark gray, with 1-foot carbonaceous shales at base and top 15

Shale, dark gray, medium-bedded; thin concretionary layer at top yielded brackish-water molluscs:

Melania wyomingensis Meek
Ostrea glabra glabra Meek and Hayden
Ostrea sp.
Unio danai Meek and Hayden 10

Shale, gray and brownish, sandy 13

Sandstone, gray, massive, soft, with thin concretionary layer at top 27

Shale, gray, carbonaceous, to sandy near base, few poorly exposed beds of gray, concretionary sandstone, in large part covered 69

Coal bed	3
Shale, gray, sandy	5

Fox Hills formation:

Sandstone, gray, hard, poorly bedded	6
Shale, soft, sandy, mostly covered	44
Sandstone, grayish-brown, poorly bedded to massive, with irregular, short lenses of gray concretionary sandstones. Horizon at top with numerous shells of the brackish-water species:	
Ostrea sp.	
Horizon at base with numerous shells of marine species:	
Anatina sulcatina Shumard	
Anatina? n. sp.	
Cardium whitei Dall	
Dentalium sp.	
Discoscaphites cheyennensis (Owen) Meek	
Fasciolaria? cheyennensis Meek and Hayden	
Legumen planulatum Conrad	
Mactra nitidula Meek and Hayden	
M. alta Meek and Hayden	
Melania wyomingensis Meek	
Modiola attenuata Meek and Hayden	
M. herseyi White	
Ostrea sp.	
Pholadomya subventricosa	
Sphæriola sp.	
Sphenodiscus lenticularis (Owen) Meek	
Tellina scitula Meek and Hayden	
Tellina sp.	
Yoldia scitula Meek and Hayden	23
Shale, soft, gray, sandy, mostly covered in linear valley	112
Sandstone, soft, brownish-gray, with concretionary masses; wood fragments scattered	48
Shale, soft, grayish-brown, sandy, mostly covered	24
Sandstone, gray to brown, massive, cross-bedded, with few layers of grayish-brown sandy shale, forms prominent scarp	125
Total Fox Hills formation	382

Lewis shale:

Shale, gray, with minor amount of sand at top. Thickness not measured.

Elk Mountain Road, Wyoming, Locality P. 374

The stratigraphic section at this locality differs only in details from that of the Corson Ranch and Walcott localities. The exact position of Locality P. 374 (NE. $\frac{1}{4}$ sec. 13, T. 21 N., R. 81 W.) and the areal distribution of formations in this region are shown in figure 6.

The occurrence of fossil leaves in the lower Medicine Bow formation had not been previously reported in this vicinity. The presence of the *Sphenodiscus* zone [1] of Fox Hills age directed our attention to the region, resulting in the discovery of several leaf horizons in the overlying 1200 feet of beds. Additional collections of both Fox Hills and Medicine Bow invertebrates were also secured. The measured section, indicating the lithologic characters and the position of faunal and floral zones (figure 5), is as follows:

[1] Dobbin, C. E., Bowen, C. F., and Hoots, H. W., U. S. Geol. Survey Bull. 804, 21, 1929.

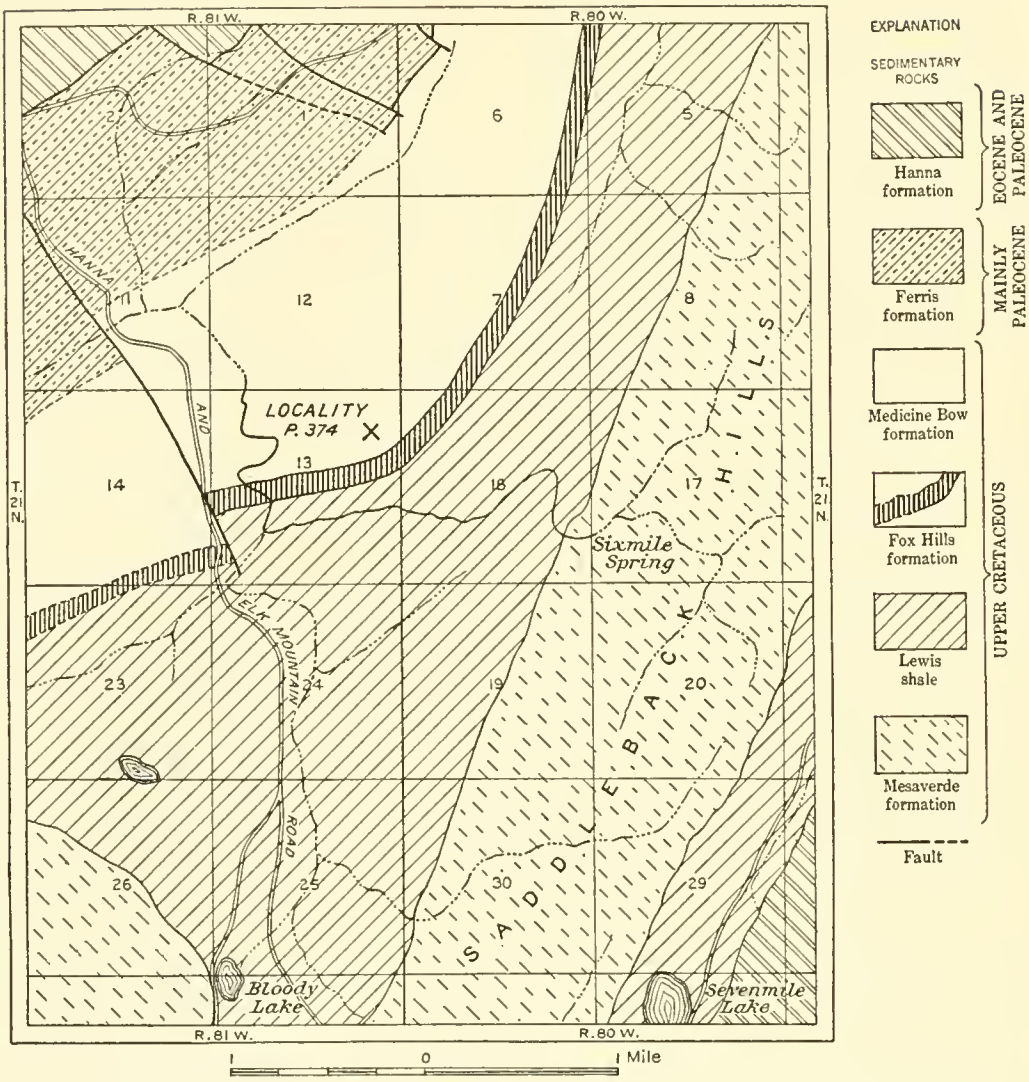

FIG. 6—Geological setting of Locality P. 374. After U. S. Geol. Survey Bull. 804, pl. 27.

Section in the Lewis, Fox Hills, and Medicine Bow formations in the NE. ¼ sec. 13, T. 21 N., R. 81 W., Wyo.

	Thickness in feet
Medicine Bow formation (lower part):	
Sandstone, fine-grained, yellow-brown, massive	35
Sandstone, gray, 2- to 4-foot beds and interbedded dark gray shales	64
Sandstone, fine-grained, yellow-brown, massive	10
Shale, soft, sandy; mostly covered	155
Shale, gray, sandy, carbonaceous, and interbedded thin, gray, fine-grained sandstones	28
Shale, soft, sandy, thinly bedded, gray to brown, interbedded with thinly bedded gray, quartzitic sandstones	48
Sandstone, massive gray-brown, fine-grained, cross-bedded near middle and at top, concretionary in upper third. Horizon 5 feet from base yielded the following fresh-water molluscs:	

Campeloma nebrascensis nebrascensis Meek and Hayden
Goniabasis tenuicarinata Meek and Hayden
Proparreysia holmesianus White
Tulotoma thompsoni White
Unio cf. U. mendax White
Unio sp. 32

Sandstone, massive, fine-grained, friable, yellow-brown 23

Shale, soft, brown, papery, somewhat sandy 12

Sandstone, fine-grained, light reddish-brown. In the basal portion were found the fossil plant species:

Celastrus taurinensis	Quercus viburnifolia
Cornophyllum wardii	Rhamnus cleburni
Ficus cockerelli	Rhamnus salicifolius
Ficus crossii	Sabalites montana
Ficus planicostata	Trochodendroides nebrascensis
Grewiopsis saportana	Typha sp.
Laurophyllum meeki	Viburnum marginatum
Myrica torreyi	

. 8

Shale, soft, sandy, gray, thinly bedded, in places carbonaceous 51

Shale, grayish-red, papery, with 2-foot coal bed at base, overlain by irregularly bedded, fine-grained, gray-brown sandstone 75

Shale, gray, papery, with thin, concretionary, fine-grained, fractured, gray-brown sandstone near middle 48

Sandstone, reddish-brown, cross-bedded, fine-grained 3

Sandstone, light brown, fine-grained with shells of the brackish-water species:
Corbula subtrigonalis subtrigonalis Meek and Hayden 15

Shale, sandy, partly carbonaceous with irregularly bedded, fine-grained, brown sandstone in middle part 33

Sandstone, brown, massive, friable, fine-grained 5

Shale, gray, sandy, papery; 2-foot coal bed overlain by a single 4-foot layer of thinly bedded brown sandstone near middle 36

Sandstone, 2-foot layer, massive, brown, fine-grained, friable 2

Sandstone, gray, hard, thinly bedded, concretionary, which yielded the following species of fossil plants:

Apeibopsis? laramiensis	Magnolia pulchra
Carpites walcotti	Magnoliophyllum cordatum
Cinnamomum affine	Myrica torreyi
Cornophyllum wardii	Phyllites wilderi
Dryophyllum subfalcatum	Quercus viburnifolia
Ficus coloradense	Rhamnus cleburni
Ficus cowanensis	Rhamnus salicifolius
Ficus planicostata	Sabalites montana
Ficus tesselata	Trochodendroides nebrascensis
Grewiopsis saportana	Typha sp.
Juglans leconteana	Viburnum marginatum
Juglans newberryi	Viburnum montanum
Laurus socialis?	Vitis stantoni
Magnolia lakesii	Zizyphus hendersoni
Magnolia nervosa	

. 5

Sandstone, gray, cross-bedded, concretionary, and lesser thickness of shales, gray, sandy 15

Sandstone, gray, massive, fine-grained 7

Shale, sandy, thinly-bedded; mostly covered 105

Sandstone, gray, fine-grained, cross-bedded 4
Shale, sandy, gray; mostly covered 53
Sandstone, gray, cross-bedded, fine-grained, quartzitic, with the following brackish-water species of molluscs:
Anodonta? sp.
Corbula subtrigonalis perundata Meek and Hayden
C. subtrigonalis subtrigonalis Meek and Hayden 3
Shale, sandy; mostly covered 16
Coal bed 1
Shale, grayish-brown, papery 12
Sandstone, grayish-brown, thinly bedded, friable 5
Sandstone, gray, quartzitic, resistant, thinly bedded 3
Shales, gray, sandy, containing gypsum and numerous shells of the brackish-water form:
Ostrea sp. 12
Sandstone, gray, quartzitic, fine-grained, thinly bedded, the bedding surfaces ripple-marked 5
Shale, grayish-brown, sandy 50
Shale, gray, papery, with shells of the brackish-water form:
Ostrea sp. 20
Sandstone, grayish-brown, fine-grained, cross-bedded 10
Sandstone, gray, fine-grained, quartzitic 6
Shale, gray, sandy, with shells of the brackish-water form:
Ostrea sp. 10
Sandstone, grayish-brown, cross-bedded, friable 3
Shale, gray, sandy, partly covered 40
Coal bed, poorly exposed 2
Shale, gray, sandy, mostly covered 14

Fox Hills formation:
Sandstone, grayish-brown, fine-grained, friable, massive, with 2-foot beds of thinly cross-bedded, gray sandstone in middle and at base 14
Shale, gray, sandy, and irregular lenses of gray, soft sandstone 20
Sandstone, gray, lenticular, resistant, thinly cross-bedded 2
Sandstone, soft, shaly, gray, interbedded in thin irregular layers with darker grayish-brown sandy shales, in part covered 178
Sandstone, gray, massive, irregularly bedded, with large concretionary masses of harder, almost quartzitic, gray sandstone, interbedded with some gray, sandy shale. Horizon 6 feet from top yielded the following marine species:
Cardium whitei Dall
Legumen planulatum Conrad
Mactra warrenana Meek and Hayden
M. nitidula Meek and Hayden
M. alta Meek and Hayden
Sphenodiscus lenticularis (Owen) Meek
Tellina scitula Meek and Hayden 76
Sandstone, soft, gray, and shales, gray, sandy, mostly covered in valley. Thickness not measured.

Craig, Colorado, Localities P. 375 and P. 376

In this vicinity, dry gullies draining into the Yampa valley expose a discontinuous section from the massive sandstones here included in the Fox Hills formation up into the lower beds of the Medicine Bow formation. The leaf-bearing horizons in the basal beds of the latter formation are located as follows:

Locality P. 375: dry gully 200 yards west of the center of sec. 32, T. 7 N., R. 90 W., ½ mile W. 18° N. of the old Kimberly coal mine.

Locality P. 376: southwest side of ridge, SE. $\frac{1}{4}$ sec. 1, T. 6 N., R. 90 W., $\frac{1}{4}$ mile northeast of the Kolasch ranch house.

Both of these localities were reported to me by Dr. T. W. Stanton of the U. S. Geological Survey [1] as having yielded fossil plants from the basal beds of the so-called "Laramie" formation. The exact position of the localities and the areal distribution of formations in this region are shown in figure 7.

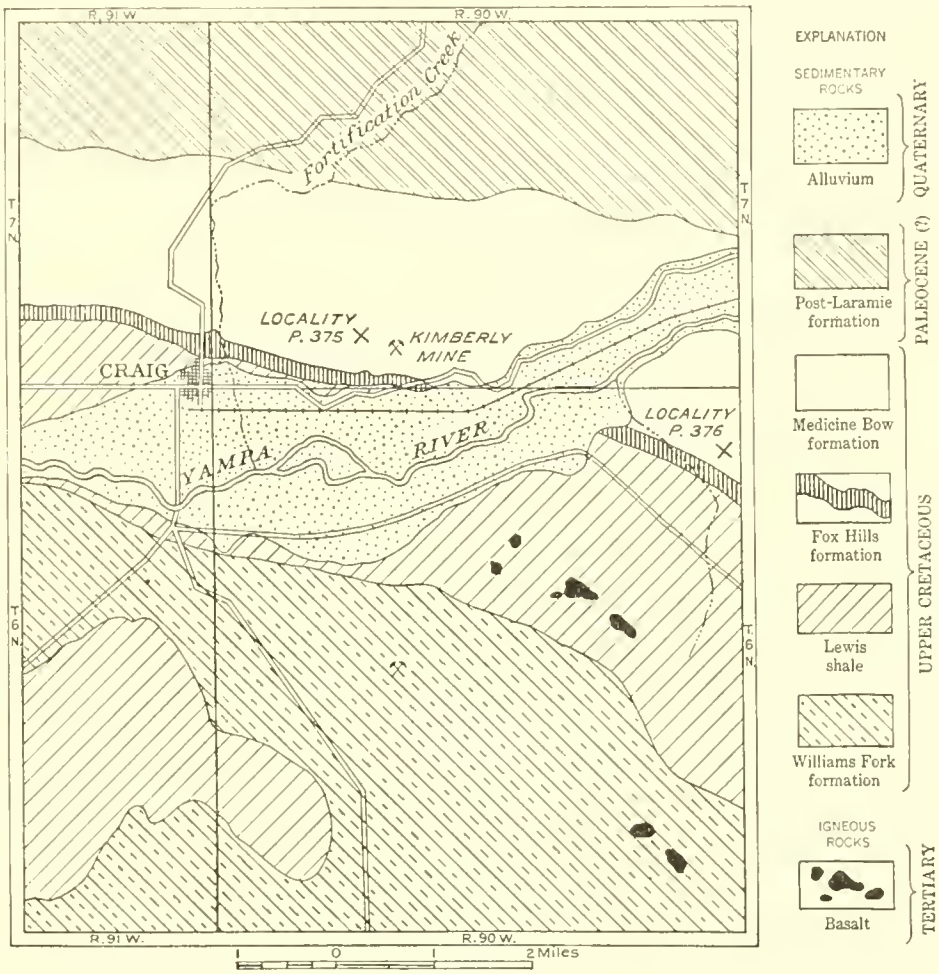

FIG. 7—Geological setting of Localities P. 375 and P. 376. After U. S. Geological Survey Bull. 297.

In view of the poor exposures in the vicinity of Craig, the measured section given below was taken farther west along the strike, in the dry valley walls of Spring Creek, 24 miles W. 10° N. of Craig. Here the section is well exposed in steeply dipping beds from the Williams Fork formation up through the Lewis, Fox Hills, Medicine Bow, and Post-"Laramie" formations. Exact stratigraphic positions with relation to the units exposed near Craig wereea sily determined by the persistenee of the two massive, fossiliferous sandstones of the Fox Hills above the well-defined Lewis shales,[2] and the presence in both regions of a persistent coal

[1] Stanton, T. W., written communication, June 8, 1935.
[2] Hancock, E. T., U. S. Geol. Survey Bull. 757, 22, 1925.

bed lying between the massive sandstones of the Fox Hills. The precise position of the leaf-bearing horizons may be up to 100 feet in error owing to the slight thickening of the recognizable units toward the west. The section, showing lithology, thickness, and the position of faunal and floral horizons (see figure 5), is as follows:

Section in the Lewis, Fox Hills, and Medicine Bow formations in sec. 10, R. 95 W., T. 7 N., Colorado

	Thickness in feet
Medicine Bow formation (lower part):	
Sandstone, grayish-brown, massive, resistant, lenticular, interbedded with thin, gray, papery, clay shales; shale bed at top contains the brackish-water form: Ostrea sp.	90
Coal bed	2
Shale, gray, sandy, with lenses of soft, gray sandstone	10
Sandstone, grayish-white, massive, resistant	10
Sandstone, gray, massive, interbedded with softer, thinly bedded, shaly sandstones	90
Shale, dark gray, sandy, with few interbedded lenses of soft sandstone	83
Sandstone, gray, massive, resistant; approximate position of resistant sandstone in the Craig area which yielded the following species of fossil plants (Locality P. 375):	
Carpites walcotti; Cinnamomum affine; Credneria protophylloides; Cyperacites sp.; Ficus crossii; Ficus planicostata; Magnoliophyllum cordatum; Myrica torreyi; Phyllites craigensis; Phyllites trillioides; Quercus viburnifolia; Sabalites eocenica; Sequoia nordenskiöldi; Trochodendroides nebrascensis; Typha sp.	3
Sandstone, grayish-white, soft, shaly, thinly bedded	42
Shale, soft, sandy, with thin lenses of fine-grained, quartzitic gray sandstones; approximate position of Kolasch ranch horizon which yielded the following species of fossil plants (Locality P. 376):	
Cinnamomum affine; Cinnamomum linifolium; Cissites lobatus; Cornophyllum wardii; Credneria protophylloides; Dombeyopsis trivialis; Dryophyllum subfalcatum; Ficus crossii; Ficus planicostata; Ficus trinervis; Juglans prærugosa; Laurophyllum meeki; Quercus viburnifolia; Rhamnus cleburni; Rhamnus salicifolius; ?Sabalites montana; Sequoia? acuminata; Sequoia nordenskiöldi; Trochodendroides nebrascensis; Viburnum marginatum; Vitis stantoni	30
Sandstone, gray, shaly, soft, grading down into massive, cross-bedded sandstone	34
Fox Hills formation:	
Sandstone, grayish-white, fairly resistant, irregularly cross-bedded, with many scattered limonite concretions; horizon 5 feet from top yielded the following marine invertebrates:	
Acteon attenuatus Meek and Hayden; Cardium whitei Dall; Dosiniopsis sp.; Legumen planulatum Conrad; Mactra nitidula Meek and Hayden; Modiola herseyi White	

Horizon 2 feet from base yielded marine invertebrates:
Cardium whitei Dall
Lunatia concinna Meek and Hayden
Lunatia dakotensis Henderson
Mactra sp. 167

Shale, gray, papery, and thinly bedded, soft sandstone; brackish-water species at base:
Corbicula fracta fracta (Meek)
Ostrea glabra arcuatilis Meek
Ostrea sp. 10

Sandstone, gray, massive, resistant, coarse; shells of brackish-water form near middle:
Ostrea sp. 18

Shale, gray, sandy 3

Coal bed 4

Shale, gray, sandy 12

Sandstone, grayish-brown, concretionary, fine-bedding. Hancock reported the following brackish-water and marine species from this "lower massive sandstone":[1]
Anomia micronema Meek
Cardium speciosum Meek and Hayden
Ostrea glabra Meek and Hayden
Scaphites? sp.
Sphenodiscus lenticularis (Owen)?
Tellina scitula Meek and Hayden 110

Shale, gray, sandy, with irregular lenses of grayish-brown, massive, fine-grained sandstones; horizon at top yielded brackish-water species:
Anomia micronema Meek
Ostrea glabra glabra Meek and Hayden
Ostrea sp. 52

Shale, gray, sandy, interbedded with three 1-foot layers of fine-grained quartzitic, gray sandstone; marine species at base:

Acteon attenuatus Meek and Hayden	Mactra warrenana Meek and Hayden
Anomia sp.	Pholadomya sp.
Baculites sp.	Pteria sp.
Cardium whitei Dall	Tellina scitula Meek and Hayden
Dentalium sp.	Thetis circularis Meek and Hayden
Legumen planulatum Conrad	Yoldia evansi Meek and Hayden 26

Sandstone, grayish-brown, massive, fine-grained, resistant, with scattered remains of *Halymenites* 24

Shale, gray, papery, grading down into more sandy, thinly bedded shales; horizon 5 feet from top yielded fresh-water species:
Campeloma nebrascensis nebrascensis Meek and Hayden
Unio cf. U. priscus priscus Meek and Hayden
Unio sp. 35

Sandstone, gray, concretionary, resistant, with 1-foot lenses of finer-grained, gray sandstone at base containing marine species:

Anatina sulcatina Shumard	Dosiniopsis sp.
Anchura sp.	Micrabacia americana Meek and Hayden
Baculites sp.	
Cardium sp.	Tellina scitula Meek and Hayden 20

Total Fox Hills formation 481

Lewis shale:

Gray, soft, clay shales, in part papery, in part sandy. Thickness not measured.

[1] Hancock, E. T., U. S. Geol. Survey Bull. 757, 22, 1925.

COMPOSITION OF THE FLORA

SYSTEMATIC RELATIONSHIPS

The flora of the lower Medicine Bow formation, as here described, comprises 64 recognizable forms. Of these, 47 are referred to species previously described by others, 11 are described as new species, and 6 are recorded as not specifically determinable. The various divisions of the plant kingdom are represented as follows: Dicotyledonæ, 45 species; Monocotyledonæ, 8 species; Coniferales, 2 species; Equisetales, 1 species; Filicales, 3 species; position uncertain, 5 species. Within most of these divisions, and in particular within the Dicotyledonæ, the systematic allocation to existing genera, and in some cases to families, is subject to revision. As is discussed under each species in the section on Systematic Palæobotany, references to modern genera have previously been made on the basis of leaf characters which in many cases seem only remotely comparable to the designated genera. Such forms might better have been placed in non-committal form genera until conclusive evidence of their systematic status had been obtained, but are here included under their assigned names to avoid confusion.

In the following systematic list of species of the lower Medicine Bow flora, the genera marked with an asterisk are of doubtful botanical significance.

Pteridophyta
- Filicales
  - **Asplenium? coloradense* Knowlton
  - **Dryopteris? carbonensis* Knowlton
  - **Aneimia* sp.
- Equisetales
  - *Equisetum* sp.

Spermatophyta
- Gymnospermæ
  - Coniferales
    - *Sequoia nordenskiöldi* Heer
    - **Sequoia? acuminata* Lesquereux
- Angiospermæ
  - Monocotyledonæ
    - Typhaceæ
      - *Typha* sp.
    - Pandanaceæ
      - *Pandanites corsoni* Dorf
    - Cyperaceæ
      - *Cyperacites* sp.
    - Palmæ
      - *Sabolites montana* (Knowlton) Dorf
      - *Sabalites eocenica* (Lesquereux) Dorf
      - **Palmocarpon? subcylindricum* Lesquereux
    - Cannaceæ
      - *Canna* cf. *C.? magnifolia* Knowlton
    - Zingiberaceæ
      - **Zingiberites dubius* Lesquereux
  - Dicotyledonæ
    - Myricaceæ
      - **Myrica torreyi* Lesquereux
    - Juglandaceæ
      - **Juglans leconteana* Lesquereux
      - *Juglans newberryi* Knowlton
      - *Juglans prærugosa* Knowlton
    - Fagaceæ
      - *Dryophyllum subfalcatum* Lesquereux
      - **Quercus viburnifolia* Lesquereux
    - Moraceæ
      - *Ficus planicostata* Lesquereux
      - **Ficus cockerelli* Knowlton
      - **Ficus trinervis* Knowlton
      - **Ficus crossii* Ward
      - **Ficus tesselata* Lesquereux
      - *Ficus coloradensis* Cockerell
      - **Ficus cowanensis* Knowlton
    - Platanaceæ
      - *Credneria protophylloides* Knowlton
    - Nyctaginaceæ
      - **Pisonia? racemosa* Lesquereux
    - Lauraceæ
      - *Cinnamomum linifolium* Knowlton
      - *Cinnamomum affine* Lesquereux
      - *Laurophyllum meeki* Dorf
      - *Laurus socialis* Lesquereux?
    - Trochodendraceæ
      - *Trochodendroides nebrascensis* (Newberry) Dorf
    - Magnoliaceæ
      - *Magnolia lakesii* Knowlton
      - *Magnolia dakotana* Berry

Magnolia nervosa (Knowlton) Brown
Magnolia pulchra Ward
Magnoliophyllum cordatum Dorf
Leguminosæ
Leguminosites arachioides minor Berry
Anacardiaceæ
Pistacia eriensis Knowlton
Celastraceæ
**Celastrus taurinensis* Ward
Rhamnaceæ
**Rhamnus salicifolius* Lesquereux
**Rhamnus cleburni* Lesquereux
Zizyphus hendersoni Knowlton
Vitaceæ
Cissites lobatus Dorf
Vitis stantoni (Knowlton) Brown
Tiliaceæ
**Apeibopsis? laramiensis* Knowlton
Grewiopsis saportana Lesquereux
Cornaceæ
Cornophyllum wardii Dorf
Bignoniaceæ
**Dombeyopsis obtusa* Lesquereux
**Dombeyopsis trivialis* Lesquereux
Caprifoliaceæ
Viburnum marginatum Lesquereux
Viburnum montanum Knowlton
Position Uncertain
Palæoaster inquirenda Knowlton
Carpites walcotti Dorf
Carpites glumæformis Lesquereux
Phyllites craigensis Dorf
Phyllites wilderi Dorf
Phyllites conwayi Dorf
Phyllites colubrinoides Dorf
**Phyllites trillioides* Dorf
Phyllites sp.
Bracts (?)

QUANTITATIVE ANALYSIS

For the purposes of both ecologic inferences and geologic correlation, it has become increasingly instructive to make quantitative leaf-counts at localities where a large number of individual specimens can be obtained. In the Medicine Bow formation only 3 localities have furnished a sufficient number of specimens for consideration. At all 6 localities the plant-bearing horizons were found to be within discontinuous, lenticular units, making extensive quarrying for quantitative studies impossible. At those localities where less than 200 specimens could be secured a careful record was kept of the order of dominance of the various species.

The leaf counts at Localities P. 372, P. 374, and P. 376 are shown in table 1. At the remaining 3 localities the order of relative abundance of those species represented by more than 5 specimens is as follows:

Locality P. 371	*Locality P. 373*	*Locality P. 375*
1. Dryophyllum subfalcatum	1. Ficus planicostata	1. Myrica torreyi
2. Ficus trinervis	2. Myrica torreyi	2. Sequoia nordenskiöldi
3. Ficus tesselata	3. Viburnum marginatum	3. Ficus planicostata
4. Pistacia eriensis	4. Rhamnus salicifolius	4. Magnoliophyllum cordatum
5. Ficus planicostata	5. Rhamnus cleburni	5. Sabalites eocenica
6. Phyllites colubrinoides	6. Pistacia eriensis	6. Typha sp.
	7. Carpites walcotti	7. Trochodendroides nebrascensis
	8. Magnoliophyllum cordatum	
	9. Trochodendroides nebrascensis	
	10. Cinnamomum affine	

The most abundant leaves are clearly those of *Ficus planicostata*, with 25.6 per cent of the 1700 specimens from 3 localities, and 5th, 1st, and 3rd, respectively, in order of dominance at the other 3 localities. The remaining dominants in their apparent relative order are as follows: *Viburnum marginatum, Myrica torreyi, Dryophyllum subfalcatum, Grewiopsis saportana, Magnoliophyllum cordatum, Rhamnus salicifolius, Rhamnus cleburni,* and *Trochodendroides nebrascensis.* These 9

species make up a total of 83.7 per cent of the 1700 specimens from Localities P. 372, P. 374, and P. 376. At the remaining 3 localities these same species are consistently among the more abundant.

TABLE 1—*Leaf counts at three localities*

Species	Locality P. 372		Locality P. 374		Locality P. 376		Totals	
	No.	p.ct.	No.	p.ct.	No.	p.ct.	No.	p.ct.
1. Ficus planicostata	390	39.0	29	5.8	16	8.0	435	25.6
2. Viburnum marginatum	241	24.1	4	0.8	19	9.5	264	15.5
3. Grewiopsis saportana	3	0.3	170	34.0	—	—	173	10.2
4. Myrica torreyi	16	1.6	151	30.2	—	—	167	9.8
5. Dryophyllum subfalcatum	43	4.3	37	7.4	36	18.0	116	6.8
6. Magnoliophyllum cordatum	81	8.1	2	0.4	—	—	83	4.9
7. Rhamnus cleburni	67	6.7	4	0.8	11	5.5	82	4.8
8. Rhamnus salicifolius	11	1.1	24	4.8	31	15.5	66	3.9
9. Trochodendroides nebrascensis	2	0.2	31	6.2	4	2.0	37	2.2
10. Dombeyopsis trivialis	20	2.0	2	0.4	9	4.5	31	1.8
11. Cornophyllum wardii	—	—	20	4.0	8	4.0	28	1.6
12. Cissites lobatus	21	2.1	—	—	6	3.0	27	1.6
13. Cinnamomum affine	14	1.4	3	0.6	4	2.0	21	1.2
14. Quercus viburnifolia	7	0.7	2	0.4	10	5.0	19	1.1
15. Ficus crossii	12	1.2	2	0.4	3	1.5	17	1.0
16. Credneria protophylloides	—	—	—	—	10	5.0	10	0.6
Totals	928	92.8	481	96.2	167	83.5	1576	92.6
Total number of leaves counted	1000		500		200		1700	

Where fossil florules can be collected from a number of scattered localities in a single formation, reliable information concerning relative abundance of species can also be derived from a consideration of those species which occur at the largest number of localities. The relative order of dominance from this point of view, summarized from the local distribution of species at the 6 Medicine Bow localities (table 4), is as follows:

1. Ficus planicostata ..... 6 localities
2. Dryophyllum subfalcatum 5
3. Magnoliophyllum cordatum 5
4. Rhamnus salicifolius 5
5. Trochodendroides nebrascensis 5
6. Quercus viburnifolia 5
7. Cinnamomum affine 5
8. Viburnum marginatum 4
9. Myrica torreyi 4
10. Rhamnus cleburni 4

A comparison of this list with the 9 dominants based on leaf counts shows that 8 of the latter are among the 10 most widely distributed at the various Medicine Bow localities. There is thus a considerable degree of correspondence between the most abundant species in the individual florules and the most widespread species in the flora as a whole. Only a single species, *Grewiopsis saportana*, among the

9 leaf-count dominants is recorded from less than 4 of the 6 localities. On the other hand there are 2 species, *Quercus viburnifolia* and *Cinnamomum affine*, which are more common in distribution than in individual abundance.

LEAF CHARACTERS

An analysis of certain structural characters of modern dicotyledonous leaves of a given area can, with reasonable accuracy, be utilized to indicate the environmental conditions of growth. Bailey and Sinnott [1] have studied such leaf characters as size, venation, and margin in floras of the various climatic zones of the world and have shown that there is, in the first place, a gradual increase in the proportion of entire-leaved dicotyledons from the forests of the cold temperate zone southward into the warm temperate, subtropical, and tropical zones. A few of their representative areas are shown in the following list:

	Per cent entire-leaved
Cold temperate zone:	
Central Russia	28
East-central North America	28
France	44
Warm temperate zone:	
East-central China	48
Southeastern United States	49
Los Angeles region	54
Subtropical and tropical zone:	
Hongkong	71
Bombay	72
West Indies	76
Florida	83
Malay States	86

Sinnott and Bailey also pointed out that large leaves, compound leaves, and pinnate leaves are most abundant in the lowland tropics and decrease proportionately into the subtropical and temperate zones.[2]

The application of several of these criteria to fossil floras was suggested and attempted by Bailey and Sinnott with considerable success. Among others, the early Tertiary Florissant and Green River floras of the Rocky Mountains, with 33 and 29 per cent, respectively, of entire-margined leaves appeared to indicate temperate conditions. In contrast, the Eocene Wilcox flora of the Gulf coast, with 83 per cent of entire-margined leaves, indicated subtropical conditions. These general conclusions have been amply corroborated by the studies of the genera and species of the several floras in question. Chaney and Sanborn [3] have more recently applied similar criteria to the Eocene Goshen flora of Oregon, and have added the textural character and the presence or absence of a dripping point as useful leaf characters for the determination of climatic conditions. Their conclusion that

[1] Bailey, E. W., and Sinnott, I. W., Science, n. s., vol. 41, 832, 1915.
[2] Sinnott, I. W., and Bailey, E. W., Amer. Jour. Bot., vol. 2, table I, 1915.
[3] Chaney, R. W., and Sanborn, E. I., Carnegie Inst. Wash. Pub. No. 439, 18, 1933.

the Goshen flora was subtropical is in close agreement with their inferences based on the modern distribution of related species.

The results of the analysis of leaf characters of the dicotyledons in the Medicine Bow floras are shown in table 2. Also introduced in this table are the analyses

TABLE 2—*Leaf characters of dicotyledons, showing relative percentages in each category*

	Margin		Length		Nervation		Texture		Organization		Dripping Point	
	Entire	Nonentire	Over 10 cm.	Under 10 cm.	Pinnate	Palmate	Thick	Thin	Simple	Compound	Present	Absent
Muir Woods, 22 species....	23	77	27	73	77	23	64	36	77	23	9	91
Bridge Creek, 20 species....	15	85	30	70	70	30	55	45	80	20	10	90
Weaverville, 36 species.....	47	53	60	40	60	40	57	43	81	19	49	51
Medicine Bow, 42 species...	67	33	45	55	60	40	71	29	83	17	48	52
Laramie, 55 species.....	71	29	45	55	64	36	73	27	87	13	18	82
Goshen, 49 species.....	61	39	53	47	82	18	98	2	88	12	47	53
Panama forest, 41 species ..	88	12	56	44	83	17	98	2	85	15	76	24

of the Goshen flora, the Bridge Creek flora, the modern flora of the Muir Woods, California, the modern Panama flora,[1] the Eocene Weaverville flora of California,[2] and the Upper Cretaceous Laramie flora of Colorado.

In compiling table 2, I have used a somewhat different arrangement from that of Chaney and Sanborn, and of MacGinitie. The characters of margin, length, and nervation are placed in the first three columns, as they are considered more reliable and more diagnostic than the remaining characters. There are two reasons for so considering them: (1) these characters have been tested more fully in modern forests, chiefly by Bailey and Sinnott; (2) they are more readily and more accurately determinable in fossil leaves than are the remaining characters. A quantitative determination of texture in fossil leaves is somewhat more difficult, since it involves a considerable amount of personal opinion. Likewise in organization, it is often impossible to ascertain whether a fossil leaf is actually a simple leaf or a leaflet of a compound leaf. It is usually necessary in this category to resort to comparisons of the fossil leaves with modern correlatives, a procedure which completely defeats the purpose of this study, namely to make climatic inferences which shall check and supplement the inferences made on the basis of taxonomy and modern distribution of correlatives. The presence or absence of dripping point has not yet been statistically studied in a sufficient number of modern forests to be reliably used. It has been my experience, moreover, that it is often a matter of opinion as to just how abrupt and elongate a leaf tip must be to be considered a dripping point. I have also been forced to consider dripping points absent from many fossil leaf species merely because the tip was not preserved, a condition which actually may have resulted from the very presence of a fragile, easily destroyed dripping point.

[1] Chaney and Sanborn, ibid., 19–21.
[2] MacGinitie, H. D., Carnegie Inst. Wash. Pub. No. 465, 113, 1937.

In the interpretation and application of the data presented in table 2, it is evident in the first place that on the basis of margin characters the Medicine Bow association is comparable to forests approaching the subtropical in aspect. The large number of entire-leaved species (67%) is only 4% less than Bailey and Sinnott's lowest figure for subtropical forests. Among fossil floras the Medicine Bow assemblage is of decidedly warmer aspect than the floras of the Bridge Creek (15%), the Green River (29%), and the Florissant (35%); the Wilcox flora, on the other hand, appears to be more subtropical (83%). The Goshen and Laramie floras are more nearly similar to the Medicine Bow in percentage of entire-leaved species. The Goshen flora (61%), according to Chaney and Sanborn,[1] indicates a humid, subtropical climate. The Laramie flora (71%) has unfortunately not as yet been thoroughly studied with a view to accurate postulation of climatic conditions.

In the column under "Length" in table 2, the percentage of large leaves in the Medicine Bow flora shows likewise its closest relationship to that of the Goshen flora. In nervation characters a closer similarity is shown to the Weaverville flora, which MacGinitie[2] has described as a warm temperate association, comparable to the modern flora of southern Alabama. Although the remaining leaf characters are not regarded as sufficiently trustworthy criteria for individual consideration, they tend to substantiate the similarity of the Medicine Bow species to those of the subtropical Goshen flora on the one hand and the warm temperate Weaverville flora on the other.

To summarize the inferences made on the basis of reliably tested leaf characters, it is evident that the Medicine Bow flora is distinctly not a cool temperate assemblage, but is intermediate in character between warm temperate and subtropical, more nearly approaching the latter.

PAST CLIMATIC CONDITIONS AS INDICATED BY THE FLORA

In addition to climatic studies based upon leaf characters, environmental conditions of the past may also be estimated by comparing the fossil species of a given flora with their nearest living relatives; it may be inferred that the past conditions were analogous to those under which the majority of living relatives grow.

The application of this method to the lower Medicine Bow flora encounters several difficulties. In the first place, many of the fossil species are not generically comparable to any living forms which have come to my attention. This may mean one of at least three things: (1) these genera may not have survived from the Upper Cretaceous to the present; (2) they may be ancestral types from which descendants with somewhat different leaf characters have since evolved; or (3) they may belong to genera with which I am unfamiliar. In the second place, even when identifications are more certain, it cannot be established that in the Upper Cretaceous a genus responded to climatic influences precisely as it does today. This difficulty is in a large measure overcome by placing less stress upon individual genera in the fossil flora and more upon the flora as a whole. Thirdly, where close

[1] Chaney, R. W., and Sanborn, E. I., Carnegie Inst. Wash. Pub. No. 439, 57, 1933.
[2] MacGinitie, H. D., Carnegie Inst. Wash. Pub. No. 465, 113, 130, 1937.

relationships have been established between fossil forms and living genera and species, it is often difficult to determine from either literature or herbarium specimens the precise distribution and climatic requirements of the living relatives. This applies particularly to subtropical and tropical forms.

To anyone familiar with temperate forests of either hemisphere, it is apparent that the lower Medicine Bow flora is distinctly not a cool temperate assemblage. The absence of typically cool temperate genera is striking. Rather than rely on such negative evidence, I would emphasize that the majority of the lower Medicine Bow species which are comparable to living forms show close resemblances to genera now living in warm temperate and subtropical forests, as shown in table 3. Fossil species which have not been found comparable to any modern leaves have been omitted from this list.

The distribution of modern correlatives and alternatives shown in table 3 indicates that only a small number of genera are found in cool temperate assemblages. With no exceptions, moreover, these few genera are of non-restricted distribution, extending in all cases into warm temperate or subtropical associations. Some of them, such as *Nyssa, Magnolia, Drimys,* and *Viburnum* are in fact more numerous and widespread in warmer forests, and extend into the cool temperate regions only in a limited number or a limited area. The large number of generic correlatives of warm temperate and subtropical forests clearly substantiates the inferences based upon the characters of leaves of the Medicine Bow species. The relatively large number of tropical genera represented does not imply close relationship to lowland tropical forests, since none of these genera is restricted to such habitats; all of them are equally well developed in subtropical associations, and may range into the warm temperate.

A consideration of several individual families whose presence is well established in the Medicine Bow flora adds weight to the climatic inferences based upon leaf characters and the aspect of the flora as a whole. Most convincing, perhaps, is the family Palmæ, represented by *Sabalites eocenica* and *S. montana.* Although the actual genus to which these species belong may be in doubt, their reference to the palm family cannot be questioned. In the living flora, palms are typically tropical and subtropical in distribution. Their most northerly representatives range only into the warm temperate lowlands of the Atlantic Coast (*Sabal palmetto* and *Serenoa serrulata*), California (*Washingtonia filamentosa*), southern Europe (*Chamærops humilis*), and southern Asia (*Chamærops* spp. and *Rhapis* spp.). The Pandanaceæ, represented by the fossil species *Pandanites corsoni*, the Myrtaceæ (*Myrica torreyi*), the Dilleniaceæ (*Rhamnus cleburni*), and the Lauraceæ (*Laurophyllum meeki, Ficus tesselata, Rhamnus salicifolius*) are likewise typically tropical and subtropical families whose modern distribution in temperate forests is restricted to the warm lowlands bordering the subtropics.

The combined evidence presented from the study of the leaf characters of the Medicine Bow species, the distribution of closely related genera of the flora as a whole, and the climatic requirements of modern families which are represented in the fossil flora is consistent throughout in indicating warm temperate to subtropical

TABLE 3

Fossil Species	Modern Correlatives	Modern Distribution			
		Cool Temp.	Warm Temp.	Sub-trop.	Trop.
Canna cf. C.? magnifolia	Canna			x	x
	Thalia		x	x	x
Carpites walcotti	Nyssa	x	x	x	
Celastrus taurinensis	Aralia	x	x	x	
	Viburnum	x	x	x	
Cinnamomum affine	Cinnamomum		x	x	x
Cinnamomum linifolium	Cinnamomum		x	x	x
	Cocculus (Cebatha)			x	x
	Lindera	x	x	x	x
Cissites lobatus	Cissus		x	x	x
	Pterospermum			x	x
Cornophyllum wardii	Cornus	x	x	x	
	Rhamnidium			x	x
	Berchemia		x	x	
	Premna			x	x
Dombeyopsis obtusa	Ficus			x	x
	Cocculus (Cebatha)			x	x
Dombeyopsis trivialis	Cocculus (Cebatha)			x	x
	Cissus		x	x	x
Dryophyllum subfalcatum	Quercus	x	x	x	
	Castanea	x	x		
Equisetum sp.	Equisetum	x	x	x	
Ficus planicostata	Ficus			x	x
	Cocculus (Cebatha)			x	x
	Hyperbæna			x	x
	Alchornea		x	x	x
	Mallotus			x	x
	Pterospermum			x	x
Ficus cockerelli	Cissampelos			x	x
	Cocculus (Cebatha)			x	x
Ficus crossii	Magnolia	x	x	x	
Ficus tesselata	Nectandra			x	x
Ficus cowanensis	Magnolia	x	x	x	
	Laurus		x	x	
Grewiopsis saportana	Grewiopsis				x
	Callichlamys			x	x
Juglans leconteana	Maclura	x	x		
	Apocynum	x	x	x	
Juglans newberryi	Juglans	x	x	x	
	Sapindus		x	x	x

TABLE 3—*Continued*

Fossil Species	Modern Correlatives	Modern Distribution			
		Cool Temp.	Warm Temp.	Sub-trop.	Trop.
Laurus socialis?	Laurus	.....	x	x	.....
	Persea	.....	x	x	x
	Magnolia	x	x	x	.....
Magnolia nervosa	Magnolia	x	x	x	.....
Magnolia pulchra	Magnolia	x	x	x	.....
	Asimina	x	x	x	.....
Magnoliophyllum cordatum	Magnolia	x	x	x	.....
Myrica torreyi	Eugenia	.....	.....	x	x
	Jambosa	.....	.....	x	x
Pandanites corsoni	Pandanus	.....	.....	x	x
Phyllites colubrinoides	Colubrina	.....	.....	x	x
	Zizyphus	.....	x	x	x
	Paliurus	.....	x	x	.....
Phyllites craigensis	Drimys	x	x	x	.....
	Illicium	.....	x	x	.....
Phyllites trillioides	Trillium	x	x	.....	.....
Phyllites sp.	Styrax	.....	x	x	x
Pistacia eriensis	Pistacia	.....	x	x	.....
	Juglans	x	x	x	.....
	Rhus	x	x	x	.....
Rhamnus cleburni	Doliocarpus	.....	.....	x	x
	Davilla	.....	x	x	x
Rhamnus salicifolius	Persea	.....	x	x	x
	Nectandra	.....	.....	x	x
Sabalites montana	Sabal	.....	x	x	x
Sabalites eocenica	Sabal	.....	x	x	x
Sequoia nordenskiöldi	Sequoia	x	x	.....	.....
Trochodendroides nebrascensis	Tetracentron	.....	x	x	.....
Typha sp.	Typha	x	x	x	x
Viburnum marginatum	Viburnum	x	x	x	.....
Viburnum montanum	Viburnum	x	x	x	.....
Vitis stantoni	Vitis	.....	x	x	x
	Totals	26	48	67	41

conditions of growth. Equally in harmony is the negative evidence of the absence of the usual cool temperate genera and the scarcity of conifers.

CORRELATION

In attempting to establish age relationships between other recorded floras and that of the lower Medicine Bow formation, three basic assumptions are made. These assumptions are: (1) that the *Sphenodiscus* zone of the Fox Hills formation is of essentially the same age wherever encountered; (2) that the *Triceratops* dinosaur zone is likewise essentially contemporaneous wherever found; and (3) that the Lance, Laramie, and lower Medicine Bow formations are conformable on the *Sphenodiscus*-bearing Fox Hills formation, and, therefore, only slightly younger than Fox Hills age.

Since none of these assumptions seems, in my opinion, doubtful or unsupported, the age of the lower Medicine Bow flora is not open to serious question. Its occurrence in beds lying within 1300 feet conformably above the *Sphenodiscus* zone of the Fox Hills formation and 2500+ feet below *Triceratops*-bearing beds clearly establishes the upper and lower limits of its time-range. Whether either or both of these zones are referred to the Upper Cretaceous or the Paleocene is immaterial to the immediate problem of correlation. In the following analysis, therefore, the lower Medicine Bow flora is regarded as a standard flora of known stratigraphic position with which other floras may be advantageously compared or contrasted.

As indicated in table 4, the Medicine Bow plant species of the present report total 64, of which 14 are either new or represented by specimens insufficient for comparison with previously recorded species. The remaining 50 species have been described or reported in other floras, which are discussed in the order of their similarity to the Medicine Bow flora.

Laramie flora—It is at once apparent from table 4 that the Laramie flora [1] of the Denver basin, Colorado, shows the closest relationship to the lower Medicine Bow flora, with 27 species in common. The same conclusion was reached by Knowlton on the basis of smaller, undescribed plant collections obtained from scattered localities in the Medicine Bow formation.[2] This close relationship indicated by the floras is amply corroborated by several lines of evidence: (1) Both the Laramie and the Medicine Bow formations occupy the same stratigraphic position conformably above the Fox Hills formation, which in both sections carries the diagnostic *Sphenodiscus;* [3] (2) both formations lie conformably or with only local disconformity below beds yielding remains of *Triceratops;* (3) in the Medicine Bow formation the plant remains were obtained from the basal 1300 feet, which is approximately the same thickness of beds from which the Laramie plants were obtained; (4) the fresh-water invertebrate fauna recorded from the Medicine Bow formation is of essentially the same character as that of the Laramie formation.[4] In my opinion there is thus sufficient unanimity of stratigraphic, palæontologic,

[1] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 130, 1922.
[2] Knowlton, F. H., ibid., 100.
[3] Dobbin, C. E., and Reeside, J. B., Jr., U. S. Geol. Survey Prof. Paper 158, 23, 1930.
[4] Henderson, J., Geol. Soc. Am., Spec. Pap. No. 3, 32, 1935.

TABLE 4—*Local and outside distribution of Medicine Bow species*

Species *	Locality P. 371	Locality P. 372	Locality P. 373	Locality P. 374	Locality P. 375	Locality P. 376	Judith River	Trinidad	Mesaverde	Fruitland-Kirtland	McDermott	Vermejo	Livingston	Adaville	Fox Hills-Colgate	Black Buttes	Laramie	Lance	Whitemud	Ravenscrag	Animas	Raton	Denver-Dawson	Evanston	Hanna	Wilcox	Fort Union	Cret. Alaska
Aneimia sp.	x								?			?					?					?	?					
Apeibopsis? laramiensis				x													x											
Asplenium? coloradense	x											x					x											
Bracts?		x																										
Canna cf. C.? magnifolia		x									x	?						x										
Carpites glumæformis		x	x													x												
Carpites walcotti			x	x	x																							
Celastrus taurinensis	x	x	x	x												x		x		x						x	x	
Cinnamomum affine		x	x	x	x	x									x		x	x										
Cinnamomum linifolium			x			x					?											x	x					
Cissites lobatus		x				x												x										
Cornophyllum wardii				x		x			x									x				x	x					
Credneria protophylloides					x	x						x																
Cyperacites sp.	x	x	x		x																							
Dombeyopsis obtusa		x						x				x					x						x					
Dombeyopsis trivialis		x	x			x											x											
Dryophyllum subfalcatum	x	x	x	x		x		x	x					x	x	x	x	x				x						x
Dryopteris? carbonensis	x															x	x											
Equisetum sp.	x	x																										
Ficus planicostata	x	x	x	x	x	x			?	x	x	x				x	x	x			x	x	x	?		?		
Ficus cockerelli	x	x	x	x												x	x	x				?				?		
Ficus trinervis	x	x				x			?	x		x				x	x	x				x	x					
Ficus tesselata	x			x								x						x										
Ficus coloradensis				x					?							?	x						x		?			
Ficus cowanensis				x													x											
Ficus crossii		x		x	x	x			x						x		x	x					?					
Grewiopsis saportana		x	x	x											x	x		x										
Juglans leconteana			x	x												x	x							?				
Juglans newberryi				x													x											
Juglans prærugosa	?					x											x											
Laurophyllum meeki				x		x										x		?										
Laurus socialis?				x							x		x									x	x					
Leguminosites arachioides minor		x	x													x		?			x	x	x			x		
Magnolia dakotana	?		x															x										
Magnolia lakesii				x											x		x											
Magnolia nervosa				x								x			x			x										
Magnolia pulchra	x			x					x											x								
Magnoliophyllum cordatum	x	x	x	x	x																							
Myrica torreyi		x	x	x	x				x	x		x			x	x	x	x					x					
Palæoaster inquirenda			x									x					x	x				x						
Palmocarpon? subcylindricum		x																					x					
Pandanites corsoni		x																										
Phyllites colubrinoides	x	x																										
Phyllites craigensis					x																							
Phyllites wilderi				x																								
Phyllites conwayi	x																											
Phyllites trillioides					x																							
Phyllites sp		x																										
Pisonia? racemosa			x													x												
Pistacia eriensis	x	x	x														x											
Quercus viburnifolia		x	x	x	x	x										x	x	x					x					
Rhamnus cleburni		x	x	x		x					?					x	x	x			x	x	x			?		
Rhamnus salicifolius	x	x	x	x		x			x			x				x	x	x					?					
Sabalites montana		x		x		?			x			x					x	x					x					
Sabalites eocenica	x	x	x		x						?					x		x				x	x					
Sequoia? acuminata		x	x			x										x	x	x					x					
Sequoia nordenskiöldi					x	x												x	x	x							x	
Trochodendroides nebrascensis		x	x	x	x	x										x		x					x					
Typha sp.		x		x	x																							
Viburnum marginatum		x	x	x		x										x	x	x				x	x			?		
Viburnum montanum		x		x					x			x																
Vitis stantoni				x		x	x								x			x										
Zingiberites dubius		x																					x					
Zizyphus hendersoni		x	x	x													x											
Totals—64	18	36	27	33	15	20	1	2	8	3	3	12	1	1	8	20	27	26	1	3	3	11	18	0	0	2	2	1

* Species with outside distribution, 50.

and palæobotanic evidence to indicate essential contemporaneity between the Laramie formation of the Denver basin and at least the lower third of the Medicine Bow formation.

Lance flora—Table 4 shows that there are 26 species in common between the Lance flora and that of the lower Medicine Bow formation. This is almost as great a similarity as between the Laramie and the Medicine Bow flora. Moreover, this similarity must by simple mathematical deduction lead to the conclusion that the Lance and Laramie floras are more nearly contemporaneous than has ever previously been admitted. Knowlton maintained that the Lance flora was distinctly younger than that of the Laramie,[1] although he admitted that the Lance flora had not at that time been adequately described and that there was considerable uncertainty attached to some of the localities from which Lance plants had been collected. In an attempt to remedy both of these situations I have begun a detailed field and laboratory study of the Lance flora, which to date has yielded the following preliminary observations: (1) Of the 58 recorded localities [2] of reputed Lance plants, 14 localities are definitely at horizons in the Fort Union formation, 8 are definitely and 7 probably in the Tullock or Ludlow member of the Lance, 11 are definitely and 9 probably in the Hell Creek member of the Lance, 1 is definitely in the Colgate member of the Fox Hills sandstone, and the remaining 8 localities are of very doubtful stratigraphic or geographic position; (2) the list of Lance plant species published by Knowlton in 1919 [3] was at that date neither complete nor reliable, and must be completely revised to be of scientific value; (3) the treatment of the Lance flora as a single unit flora will lead to further confusion; pending a more thorough investigation, it is apparent even in a preliminary enumeration of species that the flora of the Hell Creek member of the Lance is more closely allied to that of the Laramie, Medicine Bow, Colgate, etc., of the latest Cretaceous, whereas the floras of the Tullock and Ludlow members of the Lance are of Fort Union (Paleocene) facies; (4) the only thoroughly reliable information regarding the Lance flora is that of Berry [4] and Brown [5] on floras from the Hell Creek member; neither of these floras includes elements of Fort Union aspect.

Despite the confused state of the Lance flora, it has been possible to show a close relationship between the lower Medicine Bow flora and that of the Lance, mainly from the collections of Brown and Berry at the U. S. National Museum, and from my own collections at Princeton University. All of these collections are from the lower or Hell Creek member of the Lance, suggesting essential contemporaneity between the lower Lance, lower Medicine Bow, and Laramie formations. Here is convincing corroboration of our basic assumptions, since the lower Lance, like the Laramie and the lower Medicine Bow, is conformably just above the Fox

[1] Knowlton, F. H., op. cit., 104.

[2] Stanton, T. W., and Knowlton, F. H., Bull. Geol. Soc. Am., vol. 8, 127–156, 1897; Leonard, A. G., U. S. Geol. Survey Bull. 316, 201, 202, 1907; Knowlton, F. H., Washington Acad. Sci. Proc., vol. 11, 179–238, 1909; Knowlton, F. H., Jour. Geol., vol. 19, 369–371, 1911; Calvert, W. R., U. S. Geol. Survey Bull. 471-D, 195, 198, 1912; Winchester, D. E., Hares, C. J., Lloyd, E. R., and Parks, E. M., idem, Bull. 627, 24, 25, 1916; Rogers, G. S., and Lee, W., idem, Bull. 749, 29, 34, 1923; Hewett, D. F., idem, Prof. Paper 145, 27–35, 1926; Hares, C. J., idem, Bull. 775, 29, 1928; Dobbin, G. E., idem, Bull. 812-A, 11, 1929; Berry, E. W., idem, Prof. Paper 185-F, 127–132, 1934; Pierce, W. G., idem, Bull. 847-B, 56, 1936.

[3] Knowlton, F. H., U. S. Geol. Survey Bull. 696, 764, 1919.

[4] Berry, E. W., U. S. Geol. Survey Prof. Paper 185-F, 1934.

[5] Brown, R. W., U. S. Geol. Survey Prof. Paper (Manuscript, 1937).

Hills sandstone yielding *Sphenodiscus lenticularis*,[1] and is below or within the zone of abundant *Triceratops* remains. Further discussion of the stratigraphic and floral problems of the Lance will be presented in later papers.

Black Buttes flora—With 20 species common to the Medicine Bow formation, the flora from near Black Buttes in southwestern Wyoming is apparently comparable, though not necessarily exactly contemporaneous. The Black Buttes flora occurs in the so-called "Laramie" formation (Black Buttes coal group),[2] which in this region is said to lie stratigraphically just above the Lewis shale. Knowlton has given an excellent historical review of the work on this flora.[3] Although he at one time considered the flora of true Laramie age and equivalent to that of the Hell Creek member ("Ceratops beds") of the Lance,[4] Knowlton in his later years was inclined to regard it as younger than the Laramie, and considered the beds to lie unconformably on the massive sandstones (Fox Hills?) at the top of the Lewis shale.[5] I visited the Black Buttes region during the summer of 1936 and failed to find any evidence of the unconformity which Knowlton had proposed. Until a complete restudy and revision of the stratigraphy, palæontology, and palæobotany of this section is completed, it will be impossible to make a definite age determination of the flora. The high degree of similarity to the floras of the lower Medicine Bow formation cannot, however, be overlooked, and suggests similar age for at least some of the plant-bearing horizons of the Black Buttes group.

Denver-Dawson floras—There are 17 species in common between the floras of the Denver and associated formations [6] and those of the lower Medicine Bow. This is considered a sufficiently large number of species to indicate that at least a part of the Denver-Dawson beds are of lower Lance-Laramie age. Until a few years ago such a statement might have been considered absurd, since it was supposed that both the Dawson and the Denver (with its basal Arapahoe) were separated from the underlying Laramie by a great unconformity representing a hiatus of sufficient length to remove 14,000 feet of sedimentary rocks from the mountains to the west of the region.[7] Dane and Pierce [8] have recently shown that the Arapahoe-Denver sequence is equivalent in position and presumably in age to the Dawson, and that the great unconformity is at best of local stream-channel origin. It is, therefore, not unreasonable to expect Laramie species to extend into the Denver or Dawson. Of the 17 lower Medicine Bow species which occur in the Denver-Dawson, only four species in fact do not occur also in the underlying Laramie.

There are still many apparent differences between the large Denver-Dawson floras and those of the lower Lance, lower Medicine Bow, and Laramie formations. As Dane and Pierce have indicated, "the upper parts of the Dawson and Denver may possibly include beds of Eocene age." [9] More careful collecting will be neces-

[1] Dobbin, C. E., and Reeside, J. B., Jr., U. S. Geol. Survey Prof. Paper 158, 20, 1930.
[2] Schultz, A. R., U. S. Geol. Survey Bull. 702, 22–24, 1920.
[3] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 130, 62, 1922.
[4] Knowlton, F. H., Bull. Geol. Soc. Am., vol. 8, 136, 143, 156, 1897.
[5] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 130, 62–65, 1922.
[6] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 155, 1930.
[7] Emmons, S. F., Cross, W., and Eldridge, G. H., U. S. Geol. Survey Mon. 27, 209, 1896.
[8] Dane, C. H., and Pierce, W. G., Bull. Am. Assoc. Petr. Geol., vol. 20, no. 10, 1936.
[9] Dane, C. H., and Pierce, W. G., ibid., 1328.

sary in this region before the details of stratigraphic position, associated vertebrates, invertebrates, and plants can be used to determine the true sequence and age relationships.

Vermejo-Raton floras—The Vermejo and Raton floras were described by Knowlton [1] as two distinct floras occurring in beds which were separated by a definite unconformity. Although I have not visited this region, it seems apparent from the published descriptions of sections that the evidence for the unconformity can in most cases be interpreted as due to local stream-channeling. Table 4 shows that there are 12 and 11 Medicine Bow species in common with the Vermejo and Raton floras, respectively. In my opinion, this indicates that the unconformity, if it does exist, represents very little if any hiatus. If the Vermejo-Raton floras are combined they possess 20 species in common with the flora of the lower Medicine Bow formation, suggesting that at least a portion of the Vermejo-Raton sequence is of lower Medicine Bow age. In the Vermejo flora there are, to be sure, floral elements that suggest an age slightly older than Laramie or lower Medicine Bow. This is consistent with the upper Pierre rather than Fox Hills age assignment of the Trinidad sandstone, which lies conformably below the Vermejo. On the other hand, there are a number of Paleocene species in the Raton floras, suggesting that, as in the case of the Denver-Dawson beds, the lower portion of the Raton formation may be Cretaceous and the upper portion Paleocene and possibly younger.

Fort Union flora—The extensive Fort Union flora of the Rocky Mountain region is well known though in need of critical restudy, which is at present being undertaken by Dr. Roland W. Brown of the U. S. Geological Survey. Knowlton [2] regarded the Lance and Fort Union floras as essentially similar, a view which has often been quoted in geological reports and textbooks. In view of the close relationship now established between the lower Lance and the lower Medicine Bow floras, it is therefore surprising to find only two species in common between the lower Medicine Bow and Fort Union floras. This somewhat anomalous situation is in part explained by the discovery, as discussed under the Lance flora above, that some of Knowlton's so-called Lance collections were obtained from strata now conclusively known to be within the Fort Union formation. It has also become apparent that the lower Lance (Hell Creek) flora is quite distinct from that of the upper Lance (Tullock and Ludlow). The former is clearly of Laramie-lower Medicine Bow aspect, whereas the latter is more closely related to the flora of the Fort Union. If this tentative observation is substantiated by further studies of the Lance floras which I have already under way, it brings into harmony the evidence of the plants and the vertebrates in placing the greatest faunal and floral break at the end of lower Lance (Hell Creek) time.[3] This is still not in agreement with the evidence afforded by marine invertebrates, since the Cannonball member of the Lance, which overlies the Hell Creek member, has yielded a fauna which is said

[1] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, 223–349, 1917.

[2] Knowlton, F. H., Washington Acad. Sci. Proc., vol. 11, 218–226, 1909; Bull. Geol. Soc. Am., vol. 25, 334, 1914; U. S. Geol. Surv. Prof. Paper 155, 10, 1930.

[3] Since the completion of this manuscript, collections have been made in the lower Lance formation ("*Ceratops* beds") at its type locality. The flora of about 75 species is closely related to the Medicine Bow and Laramie floras and has little in common with the Tullock, Ludlow, and Fort Union floras.

to show a closer relationship to the underlying Fox Hills fauna of the Upper Cretaceous than to any known early Tertiary fauna.[1]

Summary—The evidence of the floras here discussed substantiates to a considerable degree the correlation of late Cretaceous and early Tertiary formations suggested previously by other lines of evidence. Figure 8 shows the generally

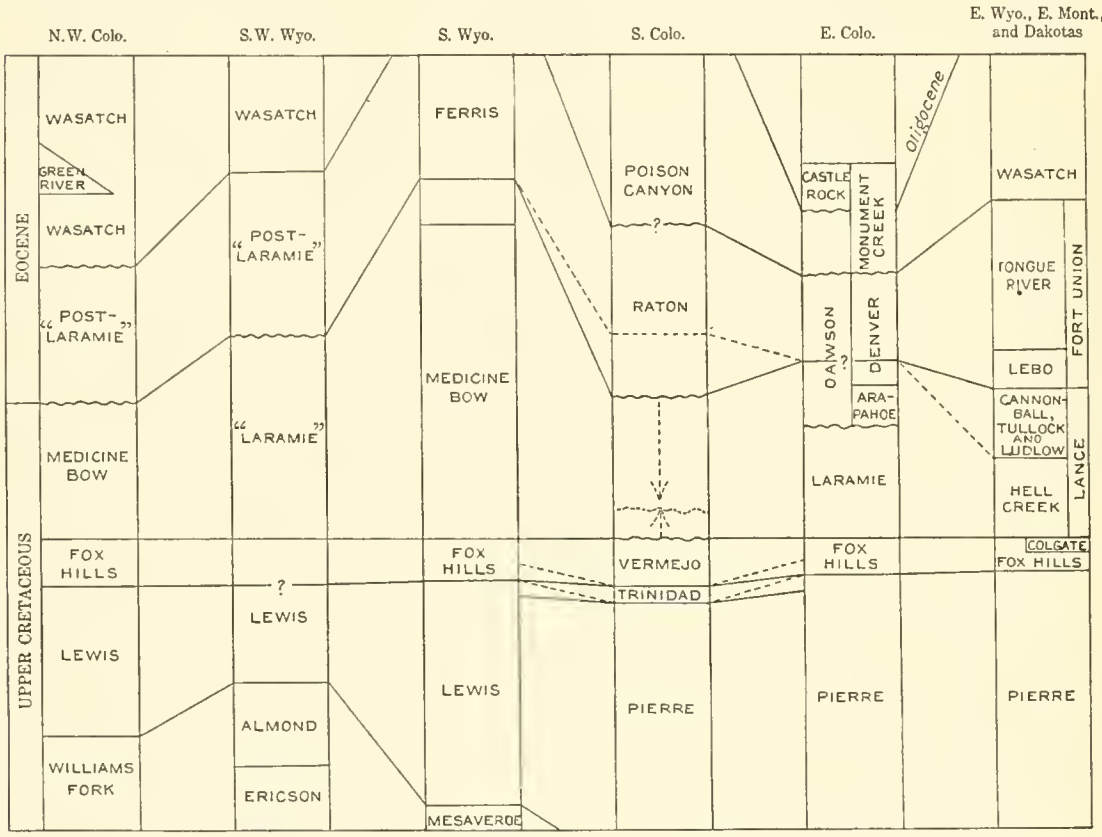

Fig. 8—Correlation chart showing proposed changes by dotted lines and arrows.

accepted correlation chart of the formations involved, modified from Miss Wilmarth's charts as suggested by the U. S. Geological Survey.[2] Further proposed changes based on the present floral studies, indicated by dotted lines and arrows, are the Laramie age of part of the Vermejo-Raton sequence and the Fort Union age of the Cannonball, Tullock and Ludlow members of the Lance formation. The present study supports the conclusion of Dane and Pierce that the lower Dawson and the Arapahoe-lower Denver should be referred to the Upper Cretaceous.

SUMMARY

The primary purpose of the present report is the description and discussion of the flora collected from the terrestrial sediments conformably overlying the

[1] Stanton, T. W., U. S. Geol. Surv. Prof. Paper 128-A, 13, 15, 1920; Dane, C. H., and Pierce, W. G., Bull. Am. Assoc. Petr. Geol., vol. 20, no. 10, 1327, 1936.

[2] Dane, C. H., and Pierce, W. G., op. cit., 1327.

youngest marine zone of the Upper Cretaceous system of southern Wyoming and northwestern Colorado.

In southern Wyoming the plant remains were collected from 4 localities in the Hanna and Carbon basins. Here the plant horizons lie within the lower third of the Medicine Bow formation. Measured sections indicate the exact positions of the plant-bearing beds with reference to the marine *Sphenodiscus* zone of Fox Hills age. Evidence is presented for the recognition of the Fox Hills formation, on both lithologic and palæontologic grounds, in the strata formerly referred to the upper Lewis or basal Medicine Bow formations.

In northwestern Colorado the plant remains were obtained from 2 localities near Craig from beds previously referred to the "Laramie" formation. The basal sandy beds of this formation have yielded marine invertebrates, including the diagnostic Fox Hills ammonite, *Sphenodiscus*. On the basis of stratigraphic, lithologic, and palæontologic evidence the section is divided into the Medicine Bow formation above and the Fox Hills formation below, the latter lying conformably above the Lewis shale as in southern Wyoming.

The plant remains from the 6 localities are treated as a unit, referred to as the lower Medicine Bow flora. Of the 64 recognizable forms 47 are referred to species previously described elsewhere, 11 are described as new species, and 6 are recorded as not specifically determinable. It is recognized that many of the generic references are of doubtful botanic validity. Although more plausible generic alternatives are suggested for most of the species, few changes in nomenclature have been made because of the lack of corroborative proof at the present time. In some species the large suites of specimens obtained have made possible new descriptions and revisions of synonymous forms. From a quantitative viewpoint 11 species are shown to be dominants on the basis of abundance of individual leaves and occurrence at the largest number of localities.

The structural characters of the dicotyledonous leaves in the flora indicate warm temperate to subtropical conditions of growth, more nearly approaching the latter. Similar climatic implications are shown by the modern distribution of families and genera whose systematic positions appear certain, and of generic alternatives suggested by similarities between the fossil leaves and those of living genera.

The age of the lower Medicine Bow formation is rather definitely established by its stratigraphic position, its relation to the *Sphenodiscus* zone and to *Triceratops*-bearing beds, and its associated fresh-water molluscs. The Laramie and lower Lance (Hell Creek member) floras are shown to be most nearly similar to that of the lower Medicine Bow and are considered essentially contemporaneous. This conclusion is supported by the relation of both the Laramie and the lower Lance formations to the *Sphenodiscus* zone and *Triceratops*-bearing beds. From a preliminary study of the Lance floras it seems evident that the Hell Creek flora is essentially of Laramie-lower Medicine Bow aspect (Upper Cretaceous) and the upper Lance (Tullock and Ludlow members) flora is of Fort Union (Paleocene) character. The latter reference is in harmony with the evidence of the vertebrate

faunas but is contradictory to the reputed Upper Cretaceous age of the Cannonball marine member of the Lance, which corresponds to the Tullock member in its position above the Hell Creek.

Other formations in the Rocky Mountain region whose floras are shown to be comparable in character and age to that of the lower Medicine Bow formation are the so-called "Laramie" of Black Buttes, Wyoming and part of the Denver-Dawson beds and of the Vermejo-Raton sequence of Colorado.

The extensive Fort Union flora of the Rocky Mountain region is considered to have little in common with that of the lower Medicine Bow. The often-quoted statement that the Fort Union and Lance floras are essentially similar in aspect is shown to be not strictly true.

SYSTEMATIC PALÆOBOTANY

GENERAL PROCEDURE

In view of the preponderance of leaves in nearly all occurrences of fossil plant remains, it is only natural that the governing principle for taxonomic work is that the leaves of trees and shrubs are sufficiently well-defined, diagnostic, and constant within genera and species to make identification possible. There are, of course, exceptional cases such as the modern *Sassafras officinale* Nees and Ebermaier, whose leaf form varies normally from entire to simply lobate to doubly lobate. Fossil specimens of such variable leaf forms of a single species might conceivably lead to their identification as three distinct species. Were it possible to obtain a large suite of such specimens, however, showing intergradations between the leaf forms, they would properly be designated a single species. Modern palæobotanic technique clearly recognizes leaf variability within certain limits of both modern and fossil species. In a thousand leaves from a single modern tree there may be found a dozen variations in size or shape or other leaf characters. Systematically arranged, however, these variants usually are constant in other characters, such as margin, venation, or character of the base or tip. In dealing with fossil specimens the normal variants of a single species can likewise be recognized, provided that a sufficient number of specimens are collected and studied. To achieve the most reliable identifications, therefore, it is desirable to obtain as large a suite of specimens of each fossil leaf type as is practicable.

In the taxonomic study of the Medicine Bow floras the collections were first sorted in the field into provisional species, based on similarity of leaf forms. From each suite of provisional species a representative suite of variants was next selected, if available, and shipped for laboratory study. Each selected specimen was then compared and contrasted with published descriptions and illustrations of the numerous Upper Cretaceous and early Tertiary species of North America. Where similarities seemed unquestionable the specimens were compared with the type specimens, nearly all of which are in the collections of the U. S. National Museum. In the larger suites of provisional species, it has often been possible to show that certain leaf types previously regarded as distinct species were merely variants of another species. In the case of *Ficus planicostata*, for example, I was faced with

the alternative of referring the large suite of specimens of this leaf type either to 8 species or to 1 species. The latter choice was inevitable, owing to the intergradations between the numerous variants. Such a course naturally has led to a large synonymy for this species as well as others whose leaves were present in large numbers. As a consequence, however, it follows that the species represented by a large number of specimens are usually more reliably identified, and long synonymies of such species tend to add to their value for both stratigraphic and purely botanical purposes.

In cases where only a few specimens of a given leaf type were obtained in the collections, the specific identifications are somewhat less positive. In some cases, for example, the lack of preservation of some integral portion of a leaf has prevented comparison with some previously described species. Final disposition of such species must of necessity await the possibility of obtaining larger suites of more complete specimens.

The generic references of many of the Medicine Bow species are open to serious doubt. Unless wholly reliable evidence to the contrary has been obtained, no new generic names have been substituted for those previously applied to the species. In many cases herbarium studies have convinced me that the generic references are unquestionably incorrect, yet my study of thousands of herbarium sheets of other genera have failed to reveal comparable leaf types. Although older generic references are thus retained for convenience and for lack of positive evidence for changes at the present time, it should be understood that such references have little botanical significance and few if any physical conclusions can be drawn from them. It is, of course, possible that many of the Upper Cretaceous genera have failed to survive in modern forests. It seems more likely, however, in view of the close similarity of some of the leaves and seeds to modern forms, that a continued search among modern plants will ultimately bring out the true botanic relationships. The few remains of seeds obtained in the collections have thus far been stubbornly unidentifiable, or at best determined only within a limit of 6 to a dozen generic possibilities. Possibly future determinations of petrified wood and spores may open the way to unsuspected relationships.

In most of the generic references previously made by other writers, their temperate zone experience has been clearly manifest. The Medicine Bow flora contains a number of distinctly warm temperate and subtropical elements, and most of the genera suggested as alternatives to present references are of low latitude families. It is, therefore, becoming increasingly evident that a better acquaintance with more southerly forests will be necessary to a proper taxonomic study of the fossil species. During the winter of 1931, I spent 3 months in the West Indies and South and Central America studying the modern forests with Dr. Ralph W. Chaney of the University of California, under the auspices of the Carnegie Institution of Washington. I have planned to extend these studies northward into Mexico and the Gulf states during the coming year. It is hoped that these experiences will lead materially to a better understanding of both the taxonomy and the ecology of the late Cretaceous floras of the Rocky Mountain region.

In the discussion of most of the species in the Medicine Bow floras, suggestions have been made, where possible, regarding what appear to be the more likely family and generic relationships. In several new species, however, pending more conclusive evidence, the leaves have been referred to the form genus *Phyllites* and the seeds to *Carpites*. Systematic descriptions of previously described species have been amended and new illustrations added where better material has been obtained.

SYNONYMS AND CHANGES OF NAMES

In the following list all names which have been changed or synonymized previously by other writers are included with those of the present report. The justification for changes in species concepts is based on either more adequate or more numerous specimens, or on closer comparison with modern leaves. A full discussion and complete bibliographic references of synonymous forms are given under each species in the systematic descriptions.

Aleurites eocenica Lesquereux = *Grewiopsis saportana* Lesquereux.
Alnus auraria Knowlton and Cockerell = *Quercus viburnifolia* Lesquereux.
Aralia taurinensis (Ward) Sanborn = *Celastrus taurinensis* Ward.
Asplenium magnum Knowlton of Hollick = *Asplenium? coloradense* Knowlton.
Asplenium martini Knowlton = *Asplenium? coloradense* Knowlton.
Berrya racemosa Knowlton = *Leguminosites arachioides minor* Berry.
Betula fallax Lesquereux (in part) = *Quercus viburnifolia* Lesquereux.
Castalia stantoni Knowlton = *Vitis stantoni* (Knowlton) Brown.
Celastrus curvinervis Ward = *Celastrus taurinensis* Ward.
Celastrus gaudini Lesquereux (in part) = *Quercus viburnifolia* Lesquereux.
Celastrus ovatus Ward = *Celastrus taurinensis* Ward.
Celastrus wardii Knowlton and Cockerell = *Celastrus taurinensis* Ward.
Cinnamomum affine Lesquereux (in part) = *Ficus trinervis* Knowlton.
Cinnamomum sp. Knowlton = *Ficus trinervis* Knowlton.
Cissus? cannoni Knowlton = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Cissus lesquereux Knowlton = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Cornus emmonsii Ward (in part) = *Ficus crossii* Ward.
Cornus impressa Lesquereux of Knowlton = *Ficus crossii* Ward.
Cornus prœimpressa Knowlton = *Ficus crossii* Ward.
Cornus studeri Heer? of Lesquereux, Ward, and Knowlton = *Cornophyllum wardii* Dorf, n. sp.
Daphnogene elegans Watelet of Ward = *Laurophyllum meeki* Dorf, n. sp.
Diospyros? ficoidea Lesquereux (in part) = *Laurophyllum meeki* Dorf, n. sp.
Dryophyllum aquamarum Ward = *Dryophyllum subfalcatum* Lesquereux.
Dryophyllum bruneri Ward = *Dryophyllum subfalcatum* Lesquereux.
Dryophyllum falcatum Ward = *Dryophyllum subfalcatum* Lesquereux.
Dryophyllum (*Quercus*) *subfalcatum* Lesquereux = *Dryophyllum subfalcatum* Lesquereux.
Ficus clintoni Lesquereux = *Ficus planicostata* Lesquereux.
Ficus haddeni Knowlton = *Ficus trinervis* Knowlton.
Ficus impressa Knowlton = *Ficus planicostata* Lesquereux.
Ficus irregularis (Lesquereux) Lesquereux (in part) = *Ficus coloradensis* Cockerell.
Ficus latifolia (Lesquereux) Knowlton = *Ficus cockerelli* Knowlton.
Ficus leei Knowlton (in part) = *Ficus planicostata* Lesquereux.
Ficus neoplanicostata Knowlton (in part) = *Ficus planicostata* Lesquereux.
Ficus neoplanicostata Knowlton (in part) = *Ficus trinervis* Knowlton.
Ficus planicostata clintoni (Lesquereux) Knowlton = *Ficus planicostata* Lesquereux.
Ficus planicostata goldiana Lesquereux = *Ficus planicostata* Lesquereux.
Ficus planicostata latifolia Lesquereux = *Ficus cockerelli* Knowlton.
Ficus planicostata magnifolia Knowlton = *Ficus planicostata* Lesquereux.
Ficus prœlatifolia Knowlton = *Ficus planicostata* Lesquereux.

Ficus pratrinervis Knowlton = *Ficus trinervis* Knowlton.
Ficus pseudopopulus Lesquereux (in part) = *Ficus planicostata* Lesquereux.
Ficus? smithsoniana (Lesquereux) Lesquereux = *Rhamnus salicifolius* Lesquereux.
Flabellaria communis Lesquereux = *Sabalites eocenica* (Lesquereux) Dorf, n. comb.
Flabellaria eocenica Lesquereux (in part) = *Sabalites eocenica* (Lesquereux) Dorf, n. comb.
Fraxinus? princetoniana Knowlton = *Dryophyllum subfalcatum* Lesquereux.
Fraxinus sp. Knowlton = *Quercus viburnifolia* Lesquereux.
Grewiopsis eocenica (Lesquereux) Knowlton = *Grewiopsis saportana* Lesquereux.
Grewiopsis ficifolia Ward = *Grewiopsis saportana* Lesquereux.
Juglans laramiensis Knowlton = *Rhamnus salicifolius* Lesquereux.
Leguminosites arachioides Lesquereux of Penhallow = *Leguminosites arachioides minor* Berry.
Malapoenna louisvillensis Knowlton = *Ficus trinervis* Knowlton.
Myrica coriacea Knowlton = *Myrica torreyi* Lesquereux.
Myrica dubia Knowlton = *Myrica torreyi* Lesquereux.
Myrica oblongifolia Knowlton = *Myrica torreyi* Lesquereux.
Myrica sp. Knowlton = *Myrica torreyi* Lesquereux.
Myrica torreyi minor Lesquereux = *Myrica torreyi* Lesquereux.
Nyssa? racemosa Knowlton = *Leguminosites arachioides minor* Berry.
Palæoaster? similis Knowlton = *Palæoaster inquirenda* Knowlton.
Phyllites populoides Knowlton = *Dombeyopsis obtusa* Lesquereux.
Phyllites trinervis Knowlton = *Dombeyopsis obtusa* Lesquereux.
Pistacia hollicki Knowlton = *Pistacia criensis* Knowlton.
Platanus aceroides latifolia Knowlton (in part) = *Viburnum marginatum* Lesquereux.
Platanus guillelmæ heerii Knowlton = *Viburnum marginatum* Lesquereux.
Platanus heeri Lesquereux of Ward = *Viburnum marginatum* Lesquereux.
Platanus marginata (Lesquereux) Heer of Knowlton = *Viburnum marginatum* Lesquereux.
Platanus platanoides (Lesquereux) Knowlton (in part) = *Viburnum marginatum* Lesquereux.
Populus arctica Heer of Lesquereux (in part) = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Populus crenata Unger of Lesquereux (in part) = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Populus denverensis Knowlton = *Quercus viburnifolia* Lesquereux.
Populus jacksoni Knowlton = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Populus nebrascensis Newberry = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Populus nebrascensis var. *grandidentata* Lesquereux = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Populus nebrascensis var. *acute-dentata* Lesquereux = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Populus nebrascensis var. *longifolia* Lesquereux = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Populus nebrascensis var. *rotundata* Lesquereux = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Populus? neomexicana Knowlton = *Dombeyopsis obtusa* Lesquereux.
Populus tenuinervata Lesquereux = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Populus zaddachi Heer of Lesquereux (in part) = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Populus zeilleri (Lesquereux) Knowlton = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Protoficus zeilleri Lesquereux = *Trochodendroides nebrascensis* (Newberry) Dorf, n. comb.
Pterospermites neomexicanus Knowlton = *Ficus planicostata* Lesquereux.
Pterospermites nervosus Knowlton = *Magnolia nervosa* (Knowlton) Brown.
Quercus doljensis Pilar of Ward = *Dryophyllum subfalcatum* Lesquereux.
Quercus gracilis Newberry = *Dryophyllum subfalcatum* Lesquereux.
Quercus purdonensis Knowlton = *Quercus viburnifolia* Lesquereux.
Quercus turbulenta Hollick = *Dryophyllum subfalcatum* Lesquereux.
Quercus whitei Lesquereux of Knowlton = *Quercus viburnifolia* Lesquereux.

Quercus whitmani Knowlton = *Dryophyllum subfalcatum* Lesquereux.
Rhamnites knowltoni Berry (in part) = *Ficus crossii* Ward.
Rhamnus belmontensis Knowlton and Cockerell = *Rhamnus salicifolius* Lesquereux.
Rhamnus brittoni Knowlton = *Rhamnus cleburni* Lesquereux.
Rhamnus elegans Newberry = *Rhamnus salicifolius* Lesquereux.
Rhamnus rectinervis Heer of Lesquereux (in part) = *Rhamnus cleburni* Lesquereux.
Rhus pseudo-meriani Lesquereux = *Dryophyllum subfalcatum* Lesquereux.
Sabal communis Lesquereux = *Sabalites cocenica* (Lesquereux) Dorf, n. comb.
Sabal? eocenica Knowlton = *Sabalites eocenica* (Lesquereux) Dorf, n. comb.
Sabal inquirenda Knowlton = *Sabalites cocenica* (Lesquereux) Dorf, n. comb.
Sabal montana Knowlton = *Sabalites montana* (Knowlton) Dorf, n. comb.
Sabal? rugosa Knowlton = *Sabalites eocenica* (Lesquereux) Dorf, n. comb.
Sabalites fructifer Lesquereux (in part) = *Leguminosites arachioides minor* Berry.
Sabalites grayanus (Lesquereux) Lesquereux (in part) = *Sabalites montana* (Knowlton) Dorf, n. comb.
Ulmus? irregularis Lesquereux = *Ficus coloradensis* Cockerell.
Viburnum contortum Lesquereux? of Knowlton = *Quercus viburnifolia* Lesquereux.
Viburnum? problematicum Knowlton = *Viburnum montanum* Knowlton.
Vitis dakotana Berry = *Vitis stantoni* (Knowlton) Brown.
Zingiberites? undulatus Lesquereux = *Zingiberites dubius* Lesquereux.
Zizyphus coloradense Knowlton = *Zizyphus hendersoni* Knowlton.

DESCRIPTIONS

Family POLYPODIACEÆ

Genus ASPLENIUM Linné

Asplenium? coloradense Knowlton

(Plate 1, Figs. 1, 2)

Asplenium? coloradense Knowlton, U. S. Geol. Surv. Prof. Paper 101, 245, pl. 30, figs. 1, 2, 1917.
Asplenium magnum Knowlton. Hollick, Torreya, vol. 2, 146, pl. 4, figs. 1, 2, 1902.
Asplenium martini Knowlton, U. S. Geol. Surv. Prof. Paper 130, 111, pl. 2, fig. 6, 1922.

Two well-preserved specimens and one fragment are clearly identical with the figured and type specimens of *Asplenium? coloradense* Knowlton from the Vermejo formation of Colorado. The shape and disposition of the pinnules are precisely as in Knowlton's figure 2, and the venation is the same, consisting of about eight or nine pairs of veins which fork once just above the midvein.

Knowlton has previously included in this species the specimens from Rockvale, Colorado which Hollick had regarded as *Asplenium magnum* Knowlton. This seems clearly justifiable. It is not possible, moreover, to distinguish this species from *Asplenium martini* Knowlton from the Laramie of Colorado. Although pointing out its close relationship, Knowlton maintained this as a separate species on the basis of "its larger size, more obtuse pinnules, and much stronger venation." [1] In view of the variation shown in the shapes of the pinnules of *Asplenium? coloradense* Knowlton, with those near the base being larger and more obtuse than the rest, and the identity of the venation, it seems impossible not to include all of these specimens in the single species which has priority. The generic reference is still open to question, pending the discovery of attached fructifications.

Occurrence—Corson Ranch, Wyoming, Loc. P. 371.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1289, 1394.

Genus DRYOPTERIS Andanson

Dryopteris? carbonensis Knowlton

(Plate 1, Figs. 3–7)

Dryopteris? carbonensis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 110, pl. 20, figs. 3–5, 1922.

This form is represented by seven specimens, five of which are figured. Most of the specimens are fragmentary or poorly preserved. The general form, size, and disposition of the pinnules, however, is adequately shown in figure 6; details of the venation appear in figure 7.

In all observable features these specimens are indistinguishable from the figures and type specimens of this Laramie species. The details of the venation are somewhat better preserved than in Knowlton's specimens, indicating, as he intimated, that some of the finer veins are once-forked near the midvein.

Knowlton has previously recorded [2] the presence of this species in the Medicine Bow formation in a manuscript list based on collections at the U. S. National Museum. Unclassified specimens (Nos. 590, *a*, *b*, *c*, *e*) of similar pinnules have been identified in the collections from Black Buttes, Wyoming, which I have consulted at the U. S. National Museum.

There is no positive evidence for the reference of this species to the genus *Dryopteris*, except a general resemblance in shape, size, and venation of pinnules. A more definite allocation cannot be made without better material and associated fertile fronds.

Occurrence—Corson Ranch, Wyoming, Loc. P. 371.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1290, 1291, 1395, 1396, 1397.

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 111, 1922.
[2] Knowlton, F. H., U. S. Geol. Surv. Bull. 696, 752, 1919.

Family SCHIZÆACEÆ

Genus ANEIMIA Swartz

Aneimia sp.

(Plate 1, Fig. 8)

The single unsatisfactory specimen figured is the only one of this form in the collections. It is clearly quite different from the other ferns but is unfortunately lacking in the characters essential for reliable identification.

The size, shape, and arrangement of the pinnules seem to relate this form to several recorded fossil species of *Aneimia* (usually misspelled *Anemia*). It differs from *A. elongata* (Newberry) Knowlton, from the Laramie and Mesaverde formations of Colorado and Wyoming,[1] only in possessing crenate rather than coarsely toothed margins. It is equally close to *A. mosbeyensis* Knowlton from the Dawson formation [2] and *A. supercretacea* Hollick from the Vermejo.[3] The marginal crenations are also apparently the main difference between our specimen and the figure of *A. occidentalis* Knowlton from the Raton formation.[4] I believe that if large, complete specimens of any of these species could be collected they might conceivably show all of the variations on a single frond which at present are considered specific differences.

The reference of all of the specimens cited to the genus *Aneimia* seems open to question. In so far as leaf morphology is concerned they might equally well be referred to *Asplenium*, *Polypodium*, or *Pteris*. In the absence of diagnostic fruiting structures, however, it is impossible to attempt a more accurate determination.

Occurrence—Corson Ranch, Wyoming, Loc. P. 371.

Collection—U. C. Mus. Pal., No. 1292.

Family EQUISETACEÆ

Genus EQUISETUM Linné

Equisetum sp.

(Plate 1, Figs. 9, 13)

The collections contain a half dozen specimens which consist in part of ribbed, jointed stems and in part of tubers connected with jointed stems. The preserved characters do not seem to me to be sufficiently diagnostic to attempt a specific determination. The reference to *Equisetum*, however, seems rather certain.

There appear to be very few figured specimens of comparable jointed stems from the late Cretaceous or early Tertiary of the Rocky Mountain region. It may be that our specimens might be comparable to several forms from the Lance or Denver, which are, unfortunately, listed simply as *Equisetum* sp.,[5] and not figured. The tubers, on the other hand, are very similar to those of *Equisetum perlævigatum* Cockerell from the Laramie formation of Colorado.[6] Close resemblance of such generalized portions of plants as underground tubers does not, however, seem to justify their being considered conspecific, or their being used for correlation purposes.

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372.

Collection—U. C. Mus. Pal., Nos. 1293, 1294.

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 112, pl. 2, fig. 2, 1922.
[2] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 155, 28, pl. 8, fig. 9, 1930.
[3] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 248, pl. 30, fig. 5, 1917.
[4] Knowlton, ibid., 285, pl. 54, fig. 2.
[5] Knowlton, F. H., U. S. Geol. Surv. Bull. 696, 259, 1919.
[6] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 113, pl. 1, figs. 8, 9, 1922.

Family TAXODIACEÆ

Genus SEQUOIA Endlicher

Sequoia? acuminata Lesquereux

(Plate 2, Fig. 1)

Sequoia acuminata Lesquereux, U. S. Geol. and Geog. Surv. Terr. Bull., vol. 1, 384, 1876; Rept. U. S. Geol. Surv. Terr., vol. 7, 80, pl. 7, figs. 15–16a, 1878; ?Knowlton, U. S. Geol. Surv. Prof. Paper 130, 114, pl. 2, figs. 7, 8, 1922.

There are only two incomplete specimens of this type in the collections. They are sufficiently well defined, however, to indicate that they are not of the spreading, two-ranked leaflets here referred to *Sequoia nordenskiöldi* Heer.

The reference to *S.? acuminata* Lesquereux is made on the basis of identity with the figured and type specimens of the Laramie forms which Knowlton questionably referred to this species, and with the original types from Black Buttes, Wyoming. On the basis of material which I have collected from the lower Lance formation near Glenrock, Wyoming, I am prepared to present evidence in a forthcoming publication that this species is not distinct from *Sequoia longifolia* Lesquereux, a conclusion which both Lesquereux and Knowlton recognized as a possibility in the reports cited above.

After surveying herbarium materials of modern conifers, I am convinced that the reference to *Sequoia* is invalid. My studies of the better material from the Lance formation have as yet not revealed the true botanical relationship of the species.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373.

Collection—U. C. Mus. Pal., No. 1295.

Sequoia nordenskiöldi Heer

(Plate 1, Fig. 10)

Sequoia nordenskiöldi Heer, Fl. Foss. Arctica, vol. 2, pt. 3, 36, pl. 2, fig. 13b, pl. 4, figs. 1a, 1b, 4–38, 1870; Newberry, U. S. Geol. Surv. Mon. 35, 20, pl. 26, fig. 4, 1898.

There are about a dozen specimens which are indistinguishable from Heer's original type figures of this species. The status of this species in North America is very unsatisfactory. In the first place, it cannot be separated from the widespread Tertiary leaf species *Sequoia langsdorfii* (Brongniart) Heer, which in turn is essentially similar to the living *S. sempervirens* Endlicher of the Pacific Coast. In the second place, cones of *Sequoia* found in the same Cretaceous strata as foliage referred partly to *S. nordenskiöldi*, and partly to *S. langsdorfii*, have recently been described as *S. dakotensis* Brown.[1] These cones are comparable to those of the living *S. sempervirens* and the Tertiary *S. langsdorfii* but are sufficiently different in significant characters to indicate that they belong to a distinct species, though not to Heer's *S. nordenskiöldi*. It seems likely, therefore, that the *Sequoia* foliage which here and elsewhere is referred to *S. nordenskiöldi* is in reality the foliage of the species whose cones are now called *S. dakotensis*. Until such time as the cones and foliage may be found in direct connection, however, it seems best to retain the widely used name *S. nordenskiöldi* for the late Cretaceous foliage of this type.

This species has been widely reported, though rarely figured, from the Lance and Fort Union of the Rocky Mountain region. I doubt if it will ever have the stratigraphic significance which can now be attached to species based on cone material.

Occurrence—Craig, Colorado, Loc. P. 375.

Collection—U. C. Mus. Pal., Plesiotype No. 1296.

Family TYPHACEÆ

Genus TYPHA Linné

Typha sp.

(Plate 1, Fig. 12)

There are about a dozen well-preserved fragments which are clearly referable to the genus *Typha*. The best of these, which is figured, shows the characteristic strong and weak parallel veins crossed and connected irregularly by short, transverse veinlets.

[1] Brown, R. W., Washington Acad. Sci. Jour., vol. 25, no. 10, 447, 1935.

So few specimens of Cretaceous or Tertiary representatives of *Typha* have been described or identified specifically that there is nothing to be gained in describing the Medicine Bow specimens as a new species. From the environmental point of view, however, the presence of this common type of aquatic monocotyledon is of significance.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372.

Collection—U. C. Mus. Pal., No. 1297.

Family PANDANACEÆ

Genus PANDANITES Dorf, n. gen.

This generic name is proposed for specimens with the characteristics of the following type species. The name is derived from the family Pandanaceæ, whose members possess spirally arranged linear leaves which are leathery, keeled, and mostly spinulose on the margins and keel.[1]

Pandanites corsoni Dorf, n. sp.

(Plate 3, Fig. 4)

Only the single specimen figured was encountered in the collections. I was at first inclined to regard this as the impression of a portion of a palm leaf. After careful study of all the available living and herbarium specimens of palms at The New York Botanical Garden, I was convinced that none of these was comparable to the fossil. It soon became apparent that its characters were very similar to those of the Pandanaceæ.

Description—Leaf of unknown length, width 5 cm., texture evidently leathery; prominent central keel, and each half of leaf marked by a subsidiary central dorsal keel; leaf surface marked by 40 to 46 longitudinal, parallel veins which are irregularly connected by transverse veinlets which may be perpendicular or oblique to the veins; margins of leaf invested with strongly spinose teeth about 5 to 6 mm. apart.

The usual description of the leaves of the Pandanaceæ emphasizes that both the leaf edges and the central keel are spinulose. In living specimens of *Pandanus*, however, I have noticed that the keel is perfectly smooth in the basal half of the leaves, becoming spinulose only in the distal half. The absence of teeth, therefore, in the fossil specimen is not considered of taxonomic importance. It is doubtful, moreover, whether spines along the keel would be discernible in a flat fossil impression.

The modern Pandanaceæ are represented in the tropics and subtropics of the Old World by three genera: *Sararanga* Hemsl. (Solomon Islands); *Freycinetia* Gaudich (East Indies to Australia and New Zealand); and *Pandanus* Linné (Asia and Africa). They are usually found in lowland marshes or along sea-coasts and are not known to occur under typically temperate conditions.

There are no fossil specimens known to me which are comparable to *Pandanites corsoni*. There is a superficial resemblance in *Bactrites pandanifolius* Berry from the Eocene Lisbon formation of Mississippi.[2] This, however, is typically a flat leaf, with a single prominent midrib and longer teeth.

This species is named for Mr. Andrew Corson, who was instrumental in the original discovery of fossil leaves on his property.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372.

Collection—U. C. Mus. Pal., Holotype No. 1298.

Family CYPERACEÆ

Genus CYPERACITES Schimper

Cyperacites sp.

(Plate 1, Fig. 11)

There are a number of specimens in the collections which are quite obviously monocotyledonous leaves with venation characters unlike those referred to *Typha*. As shown in the figured specimen they are long, 8 to 12 mm. wide, and provided with numerous fine, parallel veins about

[1] Hutchinson, J., The Families of Flowering Plants, vol. II, 159, 1934.

[2] Berry, E. W., U. S. Geol. Surv. Prof. Paper 92, 52, pl. 7, figs. 1–6, 1924.

.7 mm. apart; there appears to be a single finer vein between each pair of heavier ones; cross veins are either totally absent or very obscure. Comparable fossil remains are usually referred to the form genus *Cyperaeites*.

There is very little significance to remains of this type except to record the presence of additional monocotyledons in the plant association.

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372; north of Walcott, Wyoming, Loc. P. 373; Craig, Colorado, Loc. P. 375.

Collection—U. C. Mus. Pal., No. 1299.

Family PALMÆ

Genus SABALITES Saporta

Sabalites montana (Knowlton) Dorf, n. comb.

(Plate 3, Fig. 2)

Sabal montana Knowlton, U. S. Geol. Surv. Prof. Paper 101, 253, pl. 32, fig. 3, 1917; idem, Prof. Paper 130, 119, pl. 3, fig. 4, 1922.

Sabalites grayanus (Lesquereux) Lesquereux (in part), Rept. U. S. Geol. Surv. Terr., vol. 7, 112, pl. 12, fig. 1 (not pl. 12, fig. 2), 1878; Knowlton, U. S. Geol. Surv. Prof. Paper 155, 36, pl. 9, fig. 5, 1930.

The identification of the fossil palm leaves in the collections has led to considerable difficulty. The large size of the leaves usually makes it impossible to procure perfect or even near-perfect specimens. After an extended study of all available living and herbarium specimens of palms at The New York Botanical Garden, I have concluded, however, that better taxonomic use can be made of fossil specimens in which the petiole and the adjoining basal rays are preserved. There are a number of features which are consistently uniform in any given genus or species and are consistently different in others. These features include (1) the character of the petiole: whether unarmed or armed with thorny spines; whether flat, convex, or concave on its upper surface; whether or not it is prolonged into a rachis; (2) the character of the rachis: short or long; straight, convex, or concave sides; (3) the approximate number of rays adjoining the rachis or petiole. With all of these features preserved, however, it does not seem advisable to refer the fossil forms to modern genera unless at least one single leaf is found completely preserved. The ending *-ites* can advantageously be added to modern families or genera to indicate a close resemblance. In *Sabalites*, as here used, a resemblance to the subfamily Sabaleæ is implied.

The present species is represented by a large number of fragmentary specimens, of which the figured specimen is the only one showing the basal portion of the blade. This cannot be distinguished from the type or figured specimen of what Knowlton called *Sabal montana* from the Vermejo formation. In this species Knowlton justifiably included the specimens from the Montana group (Mesaverde formation) of Point of Rocks, Wyoming, which Lesquereux had designated as *Sabalites grayanus*. I am including also the specimen from the Denver formation which Knowlton referred to *Sabalites grayanus*. This is different in many respects from the type of *S. grayanus* (= *Sabal grayana*) from the Eocene of Mississippi,[1] but cannot be separated from *Sabalites montana*.

This species is also recorded from the Laramie formation, as indicated in the above synonymy. The specimen from the Fruitland formation which Knowlton questionably referred to this species [2] is definitely of an entirely different type.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1300.

[1] Lesquereux, Leo, Am. Philos. Soc. Trans., vol. 13, 412, pl. 14, figs. 4–6, 1869.
[2] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 98, 335, pl. 85, fig. 2, 1916.

Sabalites eocenica (Lesquereux) Dorf, n. comb.

(Plate 2, Fig. 6; Plate 3, Fig. 3)

Flabellaria eocenica Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 391, 1873; idem (1873), 380, 1874; idem (1876), 502, 1878; Rept. U. S. Geol. Surv. Terr., vol. 7, 111, pl. 13, figs. 1, 2 (not 3), 1878.
Sabal communis Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 311, 1876.
Flabellaria communis Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1875), 385, 1876.
Sabal inquirenda Knowlton, U. S. Geol. Surv. Prof. Paper 101, 288, pl. 56, 1917.
Sabal? rugosa Knowlton, U. S. Geol. Surv. Prof. Paper 101, 288, pl. 58, 1917.
Sabal? eocenica Knowlton, U. S. Geol. Surv. Bull. 696, 557, 1919.

The two figured counterparts and a number of fragmentary specimens are identical in every respect with the specimens originally called *Flabellaria eocenica* Lesquereux, and are indistinguishable from the type and figured specimens of the other species cited above.

Knowlton justifiably included all these species except *Sabal? rugosa* in his *Sabal? eocenica*. In a later report,[1] however, he confused the status of this species by referring it, along with many others, to *Sabalites grayanus* Lesquereux, originally described from the Eocene of Mississippi.[2] After an examination of the type specimens of all of these species at the U. S. National Museum, I am convinced that Knowlton's *Sabal? eocenica* can readily be distinguished by the following characters: (1) rounded and compressed aspect of the rays near their point of attachment; (2) number of folds—60 to 80; (3) slightly concave upper surface of the petiole; (4) truncate to rounded distal end of the rachis on its upper face; (5) prolongation to 6 to 8 centimeters of the abruptly narrowed, pointed, distal end of the rachis on its lower face. All the specimens which Knowlton synonymized with *S.? eocenica* exhibit this set of characteristics. The type specimen of *Sabal? rugosa*, moreover, clearly indicates that it is the upper face of the same species.

In view of the fact that Knowlton questioned the reference to *Sabal*, it seems advisable to change the generic name to the less definitive *Sabalites*. As *S. eocenica* is now conceived, it is characteristic of the uppermost Cretaceous strata of the Rocky Mountain region, occurring in the Black Buttes, the lower Raton, the lower Medicine Bow, and the lower Lance floras.[3]

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372; north of Walcott, Wyoming, Loc. P. 373.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1301, 1302.

Genus PALMOCARPON Lesquereux

Palmocarpon? subcylindricum Lesquereux

(Plate 2, Figs. 2, 3)

Palmocarpon subcylindricum Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 121, pl. 11, fig. 12, 1878.

There are three good specimens of this type in the collections. Lesquereux's description is as follows:

"Fruit oblong or subcylindrical, truncate at one end, split at the other in two diverging or slightly recurved, pointed lobes, distantly and obscurely veined toward the base."

The Medicine Bow specimens fit this description perfectly except that the veining is less obscure. Comparison with the type specimens at the U. S. National Museum indicated a close similarity in all characters except size. The veins are definitely not as far apart as Lesquereux's figures would indicate.

Knowlton has reported additional specimens of this species from the Denver formation and has questioned the reference to *Palmocarpon*.[4] I have no definite suggestion as yet regarding the true botanical affinity of the species.

Occurrence—Corson Ranch, Wyoming, Loc. P. 371.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1303, 1304.

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 155, 36, pl. 9, fig. 5, 1930.
[2] Lesquereux, Leo, Am. Philos. Soc. Trans., vol. 13, 412, pl. 14, figs. 4–6, 1869.
[3] Knowlton, F. H., Washington Acad. Sci. Proc., vol. 11, 204, 207, 1909.
[4] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 155, 42, 1930.

Family CANNACEÆ

Genus CANNA Linné

Canna cf. C.? magnifolia Knowlton

(Plate 2, Fig. 5)

The single incomplete specimen figured is the only one of this kind in the collections. It is evidently closely related to *Canna? magnifolia* and *Canna?* sp. from the Vermejo formation.[1] The only apparent difference is the absence of the faint alternation of thick and thin veins shown in Knowlton's figures and in the type specimens. Berry has reported fragments comparable to the same species from the Lance formation of South Dakota.[2] I have seen Berry's specimens at the U. S. National Museum and find them indistinguishable from the observable features of the Medicine Bow specimen.

Among living forms this type of leaf has been found to bear a general resemblance to the leaves of *Musa* and *Heliconia* of the Musaceæ, *Maranta* and *Thalia* of the Marantaceæ, and *Canna* of the Cannaceæ. The uniform thickness of the numerous veins in the fossil specimens resembles most closely the leaves of *Canna* and *Thalia*.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372.

Collection—U. C. Mus. Pal., No. 1305.

Family ZINGIBERACEÆ

Genus ZINGIBERITES Heer

Zingiberites dubius Lesquereux

(Plate 2, Fig. 4)

Zingiberites dubius Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 95, pl. 16, fig. 1, 1878; Knowlton, U. S. Geol. Surv. Prof. Paper 155, 43, 1930.

Zingiberites? undulatus Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 396, 1874. (Homonym, Heer, 1856.)

The fragment figured is the only identifiable specimen of this type in the collections. It is clearly marked by parallel veins, the heavier ones about 1.5 to 2 mm. apart, with the lighter ones intermediate and numbering 5 to 7 between each heavier pair. These venation characters are similar to those of the specimens of *Zingiberites dubius* from the Denver formation.

Both Lesquereux and Knowlton rightfully regarded this species as of doubtful taxonomic status. It is unfortunate that more complete specimens have not been found to add to the knowledge of its leaf form and characteristics.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372.

Collection—U. C. Mus. Pal., Plesiotype No. 1306.

Family MYRICACEÆ

Genus MYRICA Linné

Myrica torreyi Lesquereux

(Plate 4, Figs. 1, 2, 3)

Myrica torreyi Lesquereux, U. S. Geol. Surv. Terr., 6th Ann. Rept., 392, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 129, pl. 16, figs. 3–10, 1878; Ward, U. S. Geol. Surv., 6th Ann. Rept., 551, pl. 40, fig. 4, 1886; idem, Bull. 37, 32, pl. 14, fig. 5, 1887; Knowlton, U. S. Geol. Surv. Bull. 163, 34, pl. 6, figs. 1–3, 1900; idem, Prof. Paper 98, 90, 336, pl. 17, fig. 7, pl. 86, fig. 1, 1916; idem, Prof. Paper 101, 256, pl. 37, figs. 2–4, 1917; idem, Prof. Paper 130, 123, 1922.

Myrica torreyi minor Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 397, 1874.

Myrica coriacea Knowlton, U. S. Geol. Surv. Prof. Paper 101, 256, pl. 37, fig. 5, 1917.

Myrica dubia Knowlton, U. S. Geol. Surv. Prof. Paper 130, 123, pl. 5, fig. 3, 1922.

Myrica oblongifolia Knowlton, U. S. Geol. Surv. Prof. Paper 130, 124, pl. 21, fig. 1, 1922.

Myrica sp., Knowlton, U. S. Geol. Surv. Prof. Paper 155, 44, pl. 11, fig. 7, 1930.

Specimens of this type were present as one of the dominants in 4 of the 6 Medicine Bow localities. More than 50 well-preserved specimens were collected for study. At first I was

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 254, 255, pl. 36, fig. 3, 1917.

[2] Berry, E. W., U. S. Geol. Surv. Prof. Paper 185-F, 129, 1934.

inclined to separate these into two species, *Myrica torreyi* and *M. oblongifolia*, on the basis of differences in shape, the former with narrowly lanceolate leaves and the latter with long-elliptic to ovate-lanceolate leaves. I am now convinced, however, from gradations in shape which are apparent in the Medicine Bow collections and in various Upper Cretaceous collections at the U. S. National Museum, that all of these specimens belong to a single species whose leaf characters are amazingly consistent even though somewhat variable in size and shape. In view of the large amount of new material collected, it seems desirable to re-describe the species here.

Description (*Supplementary*)—Leaves linear to narrowly lanceolate to long-elliptic, symmetrical, narrowed gradually to a long-cuneate base and a narrowly acute tip; length variable from 5 to 15 cm., width from 1 to 5 cm.; average dimensions appear to be about 11 cm. by 2.5; greatest width at the middle of the leaf or slightly below; petiole relatively short, thick, averaging about 2 cm. in length; midrib prominent on the lower surface of the leaf; secondaries usually inconspicuous, numerous, and closely spaced, leaving the midrib at obtuse angles varying from 50° to 80°, averaging about 70°; secondaries irregularly forked, unbroken, or irregularly joined toward the margin where they meet a prominent intramarginal vein which borders the entire leaf 1 to 2 mm. from the edge; indistinct veins join the intramarginal vein to the closely spaced marginal serrations, which may be obscured by slight curling of the leaf margin; tertiary venation obscure; texture coriaceous.

Myrica torreyi, as previously conceived by various authors, is widely distributed in the late Cretaceous sediments of the Rocky Mountain region. It has previously been recorded, usually abundantly, in the Black Buttes, Lance, Laramie, Mesaverde, Fruitland, Fox Hills, and Vermejo floras. Its presence in the Denver and Dawson floras is indicated by the specimens called *Myrica* sp. and *M. torreyi minor* which are clearly variants of the normal leaf type. Likewise, *Myrica coriacea* from the Vermejo formation and *M. dubia* and *M. oblongifolia* from the Laramie, which were described as closely similar to *M. torreyi*, are obviously only variants, a view which seems the more likely because of the previous record of the normal *M. torreyi* from these same beds.

This species is an important and diagnostic index species of the late Cretaceous. It has never, to my knowledge, been reported from beds of undisputed Paleocene or younger age. Its characteristics, moreover, are usually well defined and not likely to cause confusion with other types.

The reference of this fossil species to the genus *Myrica* is open to question. I have consulted all available herbarium sheets of both eastern and western hemisphere species of *Myrica* at The New York Botanical Garden, and have failed to find any species whose leaves are comparable to the fossil specimens. The pronounced intramarginal vein observed in the fossil species is never present in the leaves of *Myrica;* neither are the fine teeth nor the closely set secondary veins. The leaves of several genera of the Myrtaceæ, on the other hand, are comparable in most respects, differing only, in some cases, in the absence of fine marginal serrations. In the genera *Amomis*, *Colycolpus*, *Calyptranthes*, *Eugenia*, and *Jambosa*, for example, most of the species possess leaves of the same general shape and almost identical venation as in the fossil specimens. The closest resemblance observed is with *Eugenia jambolana* Lam. (sheet No. 5601) and *E.* (*Phyllocalyx*) sp. (sheet No. 7559) of Brazil, and with *Jambosa jambos* (L.) Millsp. (sheet No. 15020) of Colombia; these differ from the fossil leaves only in the absence of marginal serrations. It seems likely that *Myrica torreyi* will ultimately be referred to *Myrtophyllum* Heer, indicating resemblance to the family Myrtaceæ.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Loc. P. 375.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1307, 1308, 1309.

Family JUGLANDACEÆ

Genus JUGLANS Linné

Juglans leconteana Lesquereux

(Plate 3, Fig. 1; Plate 4, Fig. 5)

Juglans leconteana Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1870), 382, 1872; idem (1876), 517, 1878; Rept. U. S. Geol. Surv. Terr., vol. 7, 285, pl. 54, figs. 10–13, 1878; Knowlton, U. S. Geol. Surv. Prof. Paper 130, 121, pl. 8, figs. 1–3, 1922.

This species is represented by 5 complete specimens and several fragments. They are indistinguishable from the specimens figured by Lesquereux and Knowlton from the Laramie and

Black Buttes floras. They are similarly indistinguishable from the original types consulted at the U. S. National Museum. These were apparently misplaced at the time Knowlton wrote Professional Paper 130, but have since been located.

Both Lesquereux and Knowlton have considered the possibility that these leaves might represent variants of *Juglans rugosa* Lesquereux or *J. rhamnoides* Lesquereux. The continued discovery of leaves of the *J. leconteana* type, and the absence of leaves of the former types in the same strata tend to corroborate the maintenance of the latter species as distinct. The reference to the genus *Juglans* seems to be based on insufficient evidence.

I have noted a close resemblance of the specimens to the leaves of *Maclura* (Moraceæ), especially *M. aurantiaca* Nutt., and *Apocynum* (Apocynaceæ), especially *A. pubescens* (?). Until some positive grounds are established for a change in name it seems best, however, to retain the old one.

Occurrence—North of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1310, 1393.

Juglans newberryi Knowlton

(Plate 4, Fig. 4)

Juglans newberryi Knowlton, U. S. Geol. Surv. Prof. Paper 130, 120, pl. 20, figs. 8–10, 1922.

The single specimen figured is the only one of this type in the collections. It is identical with the specimens of this species from the Laramie formation. Although Knowlton described the margins of his specimens as entire, the type specimens at the U. S. National Museum are somewhat obscure along the margins, like the specimen here discussed, and appear to have a few fine serrations in the upper half of the leaf.

These leaves resemble somewhat those of *Juglans crossii* Knowlton from the Green River formation,[1] differing mainly in the marginal characters and the more closely spaced secondary veins. The reference to *Juglans* may be correct, although several species of *Sapindus* have leaves which are virtually identical.

Occurrence—Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1311.

Juglans prærugosa Knowlton

(Plate 4, Fig. 6)

Juglans prærugosa Knowlton, U. S. Geol. Surv. Prof. Paper 130, 121, pl. 5, fig. 2, pl. 21, fig. 5, 1922.

This type of leaf is represented only by the complete specimen figured and several fragments. I was at first inclined to refer these to *Juglans denveriana* Knowlton [2] or *J. rugosa* Lesquereux [3] but find what seem to be important differences in shape, margin, and venation. In these characters the specimen is indistinguishable from the type and figured specimens of *J. prærugosa* from the Laramie, and fits its description perfectly. Knowlton has already reported the occurrence of this species in the Medicine Bow formation of the same region from which my collections were made.[4] I have not been able to match these specimens with any modern leaves.

Occurrence—?Corson Ranch, Wyoming, Loc. P. 371; Craig, Colorado, Loc. P. 376.

Collection—U. C. Mus. Pal., Plesiotype No. 1312.

Family FAGACEÆ

Genus DRYOPHYLLUM Debey

Dryophyllum subfalcatum Lesquereux

(Plate 5, Figs. 1, 2, 6)

Dryophyllum (*Quercus*) *subfalcatum* Lesquereux, U. S. Geol. and Geog. Surv. Terr. Bull., vol. 1, 379, 1876; idem, Ann. Rept. (1874), 301, 1876; Rept. U. S. Geol. Surv. Terr., vol. 7, 163, pl. 63, fig. 10, 1878; Knowlton, U. S. Geol. Surv. Bull. 163, 41, 1900; Washington Acad. Sci. Proc., vol. 11, 211, 1909; Brown, U. S. Geol. Surv. Prof. Paper, manuscript, 1937.

Dryophyllum aquamarum Ward, U. S. Geol. Surv., 6th Ann. Rept., 551, pl. 37, figs. 3–5, 1886; idem, Bull. 37, 26, pl. 10, figs. 2–4, 1887; Knowlton, U. S. Geol. Surv. Prof. Paper 101, 299, pl. 70, fig. 2, 1917.

[1] Lesquereux, Leo, Rept. U. S. Geol. Surv. Terr., vol. 7, 289, pl. 58, fig. 1 (= *J. denticulata* Heer), 1878.
[2] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 155, 44, pl. 12, figs. 1, 2, pl. 13, figs. 2–4, 1930.
[3] Lesquereux, Leo, Rept. U. S. Geol. Surv. Terr., vol. 7, 286, pl. 54, figs. 5, 14, pl. 55, figs. 1–9, 1878.
[4] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 100, 1922.

Dryophyllum bruneri Ward, U. S. Geol. Surv., 6th Ann. Rept., 551, pl. 36, figs. 6–9, 1886; idem, Bull. 37, 27, pl. 10, figs. 5–8, 1887; Knowlton, U. S. Geol. Surv. Prof. Paper 101, 259, pl. 53, fig. 5, 1917.
Dryophyllum falcatum Ward, U. S. Geol. Surv., 6th Ann. Rept., 551, pl. 37, fig. 10, 1886; idem, Bull. 37, 27, pl. 11, fig. 1, 1887; Knowlton, U. S. Geol. Surv. Bull. 163, 42, pl. 8, fig. 1, 1900.
Quercus gracilis Newberry, U. S. Nat. Mus. Proc., vol. 5, 504, 1883; U. S. Geol. Surv. Mon. 35, 75, pl. 67, fig. 4, 1898.
Quercus doljensis Pilar. Ward, U. S. Geol. Surv., 6th Ann. Rept., 551, pl. 36, figs. 9, 10, 1886; idem, Bull. 37, 25, pl. 9, figs. 4, 5, 1887.
Quercus whitmani Knowlton, U. S. Geol. Surv. Prof. Paper 155, 52, pl. 17, fig. 5, 1930.
Quercus turbulenta Hollick, U. S. Geol. Surv. Prof. Paper 159, 70, pl. 38, fig. 3, 1930.
Rhus pseudo-meriani Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 293, pl. 58, fig. 11, 1878.
Fraxinus? princetoniana Knowlton, U. S. Geol. Surv. Prof. Paper 130, 161, pl. 22, fig. 7, 1922.

This type of leaf is recorded from 5 of the 6 Medicine Bow localities and is usually one of the dominants. The large number of specimens collected for study were at first considered to represent 5 distinct species on the basis of identity with figured specimens. It was confusing, however, to discover that there were intermediate types present with a few characteristics of one species but the remaining characteristics of another species. After consulting the type collections at the U. S. National Museum, it has seemed necessary to regard all of these species as variants of a single rather well-defined leaf type.

The original specimen of *Dryophyllum* (*Quercus*) *subfalcatum* was collected from what is now called the Mesaverde formation at Point of Rocks, Wyoming. In the following decade Ward and Newberry independently described additional specimens of this same type of leaf from the same locality, as *Dryophyllum bruneri* Ward and *Quercus gracilis* Newberry. Neither author mentioned the work of the other nor made any reference to the similar leaf described by Lesquereux. Knowlton clarified this situation by synonymizing both species with *Dryophyllum subfalcatum*,[1] although *D. bruneri* was inadvertently restored to its specific status in Bulletin 696.

From the slightly younger Black Buttes flora of the same region specimens of essentially identical type were variously described as *D. aquamarum* Ward, *Quercus doljensis* Pilar, and *Rhus pseudo-meriana* Lesquereux. In a recent synonymy Brown has included the first of these in *Dryophyllum subfalcatum*.[2] I am including the last two, already combined as one species by Knowlton,[3] as possessing no recognizable differences. Brown has also included, on justifiable evidence, the specimens hitherto referred to *Dryophyllum falcatum* Ward, *Quercus whitmani* Knowlton, and *Q. turbulenta* Hollick from scattered beds of late Cretaceous age. To these I would add the specimen of *Fraxinus? princetoniana* from the Laramie flora.

Among my specimens which I have collected from the lower Lance east of Lance Creek, Wyoming, there are several specimens of *Dryophyllum subfalcatum* to add to the Lance occurrences recorded by Knowlton [4] and Brown.[5] Moreover, a single specimen of the same species was tentatively described as *Juglans? confusa* by Knowlton in an unfinished manuscript on a collection from the Lance formation of "Converse County," Wyoming.

As now conceived by Dr. Brown and me, this is a valuable index species of the late Cretaceous, being well defined, widespread, and usually abundant. It is unfortunate that as good use cannot be made of it in ecologic and climatic considerations owing to its uncertain botanical affinities. Cretaceous leaves of this type are usually referred without further consideration to the genus *Dryophyllum*, held to be prototypic of the family Fagaceæ. Tertiary specimens of the same general character are ordinarily referred to *Castanea* or *Quercus*, though often on insufficient evidence. I would hesitate, in the absence of seeds, to remove the present species to either *Castanea* or *Quercus*, although the resemblance to many species of these genera is admittedly striking.

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Loc. P. 376.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1313, 1314, 1315.

[1] Knowlton, F. H., U. S. Geol. Surv. Bull. 163, 41, 1900; idem, Bull. 696, 246, 1919.
[2] Brown, R. W., U. S. Geol. Surv. Prof. Paper, manuscript, 1937.
[3] Knowlton, F. H., U. S. Geol. Surv. Bull. 696, 525, 1919.
[4] Knowlton, F. H., Wash. Acad. Sci. Proc., vol. 11, 211, 1909.
[5] Brown, R. W., op. cit.

Genus QUERCUS Linné

Quercus viburnifolia Lesquereux

(Plate 6, Figs. 3, 5, 7)

Quercus viburnifolia Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 159, pl. 20, figs. 11, 12, 1878; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1876), 505, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, 46, 1888; Knowlton, Washington Acad. Sci. Proc., vol. 11, 191, 207, 1909; U. S. Geol. Surv. Prof. Paper 130, 127, 1922; idem, Prof. Paper 155, 50, pl. 16, figs. 3–8, pl. 17, fig. 1, 1930.
Alnus auraria Knowlton and Cockerell. Knowlton, U. S. Geol. Surv. Prof. Paper 155, 49, pl. 15, fig. 6, 1930.
Betula fallax Lesquereux (in part). Knowlton, ibid., 50, pl. 15, figs. 7–9, pl. 16, figs. 1, 2.
Celastrus gaudini Lesquereux (in part). Knowlton, ibid., 99, pl. 45, fig. 9 (not figs. 3, 4).
Fraxinus sp. Knowlton, ibid., 124, pl. 58, fig. 7.
Populus denverensis Knowlton, ibid., 61, pl. 23, fig. 5.
Quercus purdonensis Knowlton, ibid., 52, pl. 17, fig. 2.
Quercus whitei Lesquereux. Knowlton, ibid., 53, pl. 17, fig. 3, pl. 18, fig. 1.
Viburnum contortum Lesquereux?. Knowlton, ibid., 127, pl. 55, fig. 1.

The long synonymy cited above illustrates clearly the prevalence of this type of leaf in the Lance, Laramie, Black Buttes, Dawson, and Denver floras. The large number of "species" from the Denver flora which are here combined with *Quercus viburnifolia* might be open to criticism. After studying the type specimens at the U. S. National Museum I find it impossible, however, to segregate them into distinct species with truly recognizable differences. The alternatives were either to merge them into a single species, whose leaves are somewhat variable—though no more so than those of a single modern tree; or to separate the specimens into about 10 species based on minor differences in shape, venation, or marginal characters. To avoid rather than produce confusion, it was thought best to combine the specimens, incidentally adding greater value to the species for correlation purposes.

Specimens of this species were collected from 5 of the Medicine Bow localities. In none of these is the species as abundantly represented as it is in the collections from the Denver formation. Its presence in both the Laramie and Lance formations is reported in Professional Paper 130 cited above, as well as in an unpublished manuscript of Knowlton's seen at the U. S. National Museum. It is apparent that this species is not present in any of the extensive Fort Union or Eocene collections at the Museum, nor has it ever been reported in beds either older or younger than post-Montana Cretaceous.

The generic reference of this species to *Quercus* seems open to question. I have consulted herbarium material of all genera of the Fagaceæ and have not succeeded in finding any leaves of comparable form. The general shape, venation, and character of marginal teeth of the fossil leaves seem rather to relate them to the Betulaceæ or the Caprifoliaceæ.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Locs. P. 375, P. 376.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1316, 1317, 1318.

Family MORACEÆ

Genus FICUS (Tournefort) Linné

Ficus planicostata Lesquereux

(Plate 5, Figs. 3, 4, 5, 7)

Ficus planicostata Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 393, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 201, pl. 31, figs. 1–8, 10–12, 1878; Knowlton, U. S. Geol. Surv. Bull. 163, 52, pl. 10, fig. 4, pl. 12, figs. 2, 3 (not 4), 1900; Washington Acad. Sci. Proc., vol. 11, 211, 1909; Cockerell, Univ. Colorado Studies, vol. 7, 151, 1910; Knowlton, U. S. Geol. Surv. Prof. Paper 130, 131, 1922; idem, Prof. Paper 134, 82, pl. 9, fig. 2, 1924.
Ficus planicostata goldiana Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 399, 1874; Rept. U. S. Geol. Surv. Terr., vol. 7, 202, pl. 33, figs. 1–3, 1878; Knowlton, U. S. Geol. Surv. Prof. Paper 155, 70, pl. 28, fig. 5, 1930.
Ficus planicostata clintoni (Lesquereux) Knowlton, U. S. Geol. Surv. Bull. 152, 103, 1898; idem, Prof. Paper 101, 303, pl. 76, fig. 3, 1917.
Ficus clintoni Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 393, 1873.
Ficus planicostata magnifolia Knowlton, U. S. Geol. Surv. Prof. Paper 130, 133, pl. 10, fig. 3, 1922.
Ficus lcei Knowlton (in part), U. S. Geol. Surv. Prof. Paper 101, 261, pl. 39, figs. 2–5 only, 1917; idem, Prof. Paper 98, 338, pl. 90, fig. 2, 1917.

Ficus pseudopopulus Lesquereux (in part), Knowlton, U. S. Geol. Surv. Prof. Paper 101, 304, pl. 72, figs. 3, 4 only, 1917; idem, Prof. Paper 134, 83, pl. 7, fig. 4, pl. 9, fig. 3, 1924; idem, Prof. Paper 155, 66, only pl. 25, figs. 3–5, 1930.

Ficus neoplanicostata Knowlton (in part), U. S. Geol. Surv. Prof. Paper 101, 303, pl. 73, fig. 4, pl. 74, figs. 2, 3, pl. 76, fig. 4, 1917; idem, Prof. Paper 134, 82, pl. 9, fig. 4, 1924; idem, Prof. Paper 155, 69, only pl. 28, figs. 3–7, 1930.

Ficus prælatifolia Knowlton, U. S. Geol. Surv. Prof. Paper 98, 338, pl. 87, fig. 4, 1917.

Pterospermites neomexicanus Knowlton, ibid., 341, pl. 90, fig. 6.

Ficus impressa Knowlton, U. S. Geol. Surv. Prof. Paper 130, 134, pl. 7, figs. 1–3, pl. 16, fig. 3, 1922.

The specimens from Black Buttes, Wyoming were originally described by Lesquereux as follows:

"Leaves of medium size, subcoriaceous, entire, elliptical or broadly oval, slightly acuminate or obtuse, rounded to a short, thick, petiole, palmately three-nerved from the top of the petiole, rarely from a short distance above the base; primary and secondary nerves broad, flat, all camptodrome, as well as their divisions."

Leaves of precisely this description are by far the most abundant of all species in the Medicine Bow collections. Over 50 specimens of complete or nearly complete leaves were collected for study. In arranging this suite for identification it was apparent that there was a perfect series from small ones 1.2 by 2 cm. in dimensions to very large ones 7 by 12 cm. It was also found possible to match individual specimens perfectly with the figures and type specimens of each of the species listed in the above synonymy. These various species had been distinguished from *Ficus planicostata* by minor details, chiefly of venation, but were in each case discussed as difficult to separate from that species. They are here regarded as mere variants of the average leaf form.

In 1923 Berry discussed the difficulties involved in the taxonomic separation of leaves of this type and concluded that *Ficus planicostata* and its varieties were best considered conspecific with *Ficus mississippiensis* (Lesquereux) Berry.[1] In comparisons of my large suite with all available specimens of both these species and others at the U. S. National Museum I have found, however, that the following criteria can serve to distinguish them:

Ficus planicostata	*Ficus mississippiensis*
1. Size: Average less than 10 cm. long.	1. Size: Average more than 10 cm. long.
2. Shape: Always elliptical or broadly oval, widest near the middle.	2. Shape: Always ovate or ovate-lanceolate, widest well below the middle.
3. Tip: Always obtuse and abruptly narrowed to a blunt point.	3. Tip: Always acute and gradually narrowed from the middle of the leaf to a long, slender point.
4. Venation: Lateral primaries basilar.	4. Venation: Lateral primaries suprabasilar.

It must be admitted, of course, that it is largely a matter of taxonomic judgment as to which characters of leaves are more or less important in distinguishing one species from another. In this case, however, I feel that my conclusions were inevitable because of the constancy with which the listed characters were maintained in so large a collection of leaves of all sizes.

As here conceived, *Ficus planicostata* is a valuable index of late Cretaceous deposits in the Rocky Mountain region, though it may possibly range into the early Paleocene. It makes its first appearance in the upper Mesaverde formation of Wyoming, is well represented in the Vermejo, Raton, Fruitland, and Animas formations, and is abundant in the Laramie, Denver, and Black Buttes floras. Although it has been reported from only one locality in the Lance,[2] I have seen other specimens of it from the Lance of "Converse County," Wyoming, at the U. S. National Museum, which Knowlton referred to *Phyllites ficifolia*, new species.[3] The species has never been found in beds of indisputable Paleocene age, although collections from such beds, namely the Fort Union formation, are very extensive. Related descendants of this species, such as *Ficus mississip-*

[1] Berry, E. W., U. S. Geol. Surv. Prof. Paper 131-A, 9, pls. 6–8, 1923.
[2] Knowlton, F. H., Washington Acad. Sci. Proc., vol. 11, 211, 1909.
[3] Knowlton, F. H., unpublished manuscript.

piensis and *Ficus plinerva* Chaney and Sanborn[1] appear to have survived into the Tertiary on the Gulf coastal plain and the Pacific Coast respectively.

Among living forms I have noted a general similarity of the leaves of *Ficus planicostata* to a number of genera: *Cocculus* (*Cebatha*) and *Hyperbæna* of the Menispermaceæ, *Alchornea* and *Mallotus* of the Euphorbiaceæ, *Pterospermum* (Sterculiaceæ), *Hampea* (Bombacaceæ), *Colubrina* (Rhamnaceæ), and *Ficus* (Moraceæ). After consulting all available herbarium material of both eastern and western hemisphere representatives of these genera at The New York Botanical Garden, I am convinced that the reference to *Ficus* is not only reasonable but probably correct. A close resemblance was noted between the fossil specimens and the leaves of *Ficus colubrinæ* Standley[2] of Guatemala and *Ficus integrifolia* Elm.[3] of the Philippines. Except for their remotely toothed margins the leaves of *Ficus riedelii* Miq.[4] of Celebes are also comparable.

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Locs. P. 375, P. 376.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1391, 1319, 1320, 1321.

Ficus cockerelli Knowlton

(Plate 7, Fig. 2)

Ficus cockerelli Knowlton, U. S. Geol. Surv. Bull. 696, 273, 1919; idem, Prof. Paper 130, 132, pl. 12, fig. 2, pl. 23, figs. 1, 2, 1922.

Ficus latifolia (Lesquereux) Knowlton, U. S. Geol. Surv. Bull. 152, 102, 1898; idem, Prof. Paper 101, 304, 1917. (Homonym, Kunth, 1846.)

Ficus planicostata latifolia Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1872), 393, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 202, pl. 31, fig. 9, 1878.

There are about 10 specimens of this type, which are similar except in their slightly smaller size to the figured and type specimens of this species. I was at first inclined to regard these specimens as variants of *Ficus planicostata*. Among the large number of specimens of the latter species, however, there are none which vary in the direction of the round, broad leaves of *F. cockerelli*. The heart-shaped base and the venation of this species are also distinctive. There is a resemblance to *F. speciosissima* Ward from the Mesaverde formation[5] and *F. leei* Knowlton from the Vermejo,[6] which I believe are conspecific with each other. These, however, are decidedly more heart-shaped at the base, are longer in proportion to their width, and possess notable differences in both secondary and tertiary venation.

Ficus cockerelli is reported in the above citations to be questionably present in the Raton flora and fairly common in both the Laramie and Black Buttes floras. It is said to occur also in the Wilcox of the Gulf states.[7] I have not seen the Wilcox specimens, which Berry more recently has considered synonymous with *Ficus mississippiensis*.[8]

Among modern leaves these specimens are in my opinion more similar to the leaves of *Cocculus, Cissampelos,* and *Menispermum* (Menispermaceæ) than to any species of *Ficus* which I have seen. Except for their thinner texture, it is difficult to distinguish the fossil specimens from the leaves of *Cocculus* (*Cebatha*) *carolinus* (L.) DC.[9]

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1322.

[1] Chaney, R. W., and Sanborn, E. I., Carnegie Inst. Wash. Pub. No. 439, 66, 1933.
[2] See sheet No. 7668 at The New York Botanical Garden.
[3] See sheet No. 76244.
[4] Chaney, R. W., and Sanborn, E. I., Carnegie Inst. Wash. Pub. No. 439, 67, 1933.
[5] Ward, L. F., U. S. Geol. Surv. Bull. 37, 39, pl. 21, fig. 3, 1887.
[6] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 261, pl. 39, figs. 1, 6, pl. 40, figs. 1, 2, 1917.
[7] Berry, E. W., U. S. Geol. Surv. Prof. Paper 91, 199, 1916.
[8] Berry, E. W., U. S. Geol. Surv. Prof. Paper 131-A, 9, 1923.
[9] See sheet No. 18, Alabama, in the Princeton University herbarium.

Ficus trinervis Knowlton

(Plate 6, Figs. 1, 4)

Ficus trinervis Knowlton, U. S. Geol. Surv. Bull. 163, 42, 1900; Cockerell, Am. Mus. Nat. History Bull., vol. 24, 89, 1908; Knowlton, Washington Acad. Sci. Proc., vol. 11, 197, 1909.
Cinnamomum affine Lesquereux (in part), Rept. U. S. Geol. Surv. Terr., vol. 7, 219, pl. 37, fig. 5 only, 1878; Ward, U. S. Geol. Surv., 6th Ann. Rept., 553, pl. 67, figs. 1–3, 1886; idem, Bull. 37, 50, pl. 24, figs. 3–5, 1887.
Ficus prætrinervis Knowlton (in part), U. S. Geol. Surv. Prof. Paper 101, 263, 304, pl. 41, figs. 1–3 only, pl. 42, fig. 1, 1917; idem, Prof. Paper 98, 338, 1916; idem, Prof. Paper 155, 71, pl. 28, fig. 8 only, 1930.
Ficus haddeni Knowlton, U. S. Geol. Surv. Prof. Paper 101, 260, pl. 38, figs. 6, 7, 1917.
Malapoenna louisvillensis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 144, pl. 7, fig. 5, 1922.
Ficus neoplanicosta Knowlton (in part), U. S. Geol. Surv. Prof. Paper 155, 69, only pl. 29, figs. 3, 4, 1930.
Cinnamomum sp. Knowlton, ibid., 87, pl. 39, fig. 1.

This type of leaf is not abundant, being represented by only 6 specimens from 3 localities. None of these is perfectly complete, but enough is preserved to show that these can not be separated from the type specimens (not figured by Knowlton) of *Ficus trinervis*, and the figured and type specimens erroneously referred to *Cinnamomum affine* which Knowlton properly referred to *Ficus trinervis*. Knowlton justifiably distinguished these specimens from *Cinnamomum affine* by the character of the basal secondaries, which "pass to extreme base of the blade and arise with and at the same point as the midrib." [1] In his report on the Vermejo flora Knowlton subsequently described what he called a very closely related species, *Ficus prætrinervis*, which he distinguished from *F. trinervis* by a slight outward arching of the basal secondaries in the upper half of the blade. Since this minor difference does not appear to be consistent in my specimens or in the type specimens or duplicates at the U. S. National Museum, I feel justified in uniting these two species.

The characters which appear to be diagnostic of *Ficus trinervis* are as follows: shape broadly ovate to ovate-lanceolate; obtuse to slightly acuminate tip, and abruptly rounded decurrent base; tri-nerved from below the actual base of the blade, so that the basal laterals form the margin of the leaf down to the petiole; margin entire; lateral secondaries given off from the midrib at very acute angles, almost paralleling the midrib and finally joining the next secondaries above by marginal loops. The four species listed above as synonymous with *F. trinervis* all possess this same set of characters.

As now known, *Ficus trinervis* is present in the Medicine Bow, Mesaverde, Vermejo, Fruitland, Raton, Laramie, Lance, Denver, Dawson, and Black Buttes floras. To my knowledge it has never been reported in beds of indisputable Paleocene or later age.

The generic reference of this species to *Ficus* has in no way been substantiated by my survey of all species of this genus in the herbarium of The New York Botanical Garden. The general shape, margin, and venation of the fossil leaves are, in my opinion, more likely menispermaceous, yet I have been unsuccessful in finding a single species of this family in which the leaves are basally decurrent.

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372; Craig, Colorado, Loc. P. 376.
Collection—U. C. Mus. Pal., Plesiotypes Nos. 1323, 1324.

Ficus crossii Ward

(Plate 7, Fig. 3)

Ficus crossii Ward, U. S. Geol. Surv., 6th Ann. Rept., 552, pl. 44, fig. 7, 1886; idem, Bull. 37, 39, pl. 21, fig. 2, 1887; (*not* Knowlton, idem, Prof. Paper 130, pl. 11, fig. 2, which = *Rhamnus goldianus*).
Cornus emmonsii Ward (in part), U. S. Geol. Surv., 6th Ann. Rept., 553, pl. 47, fig. 3 only, 1886; idem, Bull. 37, 55, pl. 26, fig. 3 only, 1887.
Cornus impressa Lesquereux. Knowlton, U. S. Geol. Surv. Bull. 163, 68, 1900.
Cornus præimpressa Knowlton, U. S. Geol. Surv. Prof. Paper 130, 159, pl. 14, fig. 5, pl. 19, fig. 2a, 1922; Brown, U. S. Geol. Surv. Prof. Paper, manuscript, 1937.
Rhamnites knowltoni Berry (in part), U. S. Geol. Surv. Prof. Paper 185-F, 131, pl. 26, fig. 1, 1934.

Specimens of this type of leaf are not common but are usually rather well preserved. The specimen here figured is virtually complete in all details, which are similar to the specimens referred to the 5 distinct species above. It should be pointed out that the figures of *Ficus crossii* and *Cornus emmonsii* were not correctly drawn nor properly restored, as has been previously noted by

[1] Knowlton, F. H., U. S. Geol. Surv. Bull. 163, 43, 1900.

Knowlton.[1] The type specimens of both of these species are not distinguishable in any way from my specimens nor from the specimen of *Cornus præimpressa*. I have not seen the actual specimen of *Rhamnites knowltoni* from the Lance formation, but the figure seems quite unlike the type specimens of this species from the Eocene of the Gulf Coast,[2] and is not distinguishable from the specimens here referred to *Ficus crossii*. Such a reference is substantiated by the presence of several indistinguishable leaves in a collection which I recently made from the lower Lance near Ekalaka, Montana. In view of the discovery of more complete specimens than hitherto known, it seems desirable to amplify the descriptions previously given of this species.

Description (Supplementary)—Leaves elliptic to oval, with a broadly cuneate base and abruptly short-acuminate tip; length 8 to 10 cm.; width 5 to 6 cm.; midrib thick in depth, especially below, straight or very slightly curved; secondaries about 10–12 pairs, mainly alternate, at an angle of about 60° near the base to as low as 35° near the apex, slightly curved upward, unbranched, camptodrome, arching upward just inside the margin; tertiary veins fairly strong, mainly unbroken, at angles of 90° to the midrib near the apex to as low as 65° to the midrib in the lower half; finer veins forming an irregular meshwork; margin entire; texture firm.

This species as now known is present in the Mesaverde, Colgate, Laramie, lower Lance, and lower Medicine Bow formations, with the closely related *Rhamnites knowltoni* occurring in the Eocene of the Gulf Coast. There do not appear to be any Fort Union species with which confusion might result.

Among living forms there appear to be very few species of *Ficus* with leaves of this general character. I have surveyed the following genera at The New York Botanical Garden as alternative possibilities for comparison: *Anona* (Anonaceæ), *Cornus* and *Nyssa* (Cornaceæ), *Ficus* (Moraceæ), *Magnolia* (Magnoliaceæ), *Rhamnus* (Rhamnaceæ), *Cephalanthos* (Rubiaceæ), and *Diospyros* (Ebenaceæ). The closest resemblance among these genera was with *Magnolia*, particularly *M. virginiana* L. (= *M. glauca* L.) and the smaller leaves of *M. grandiflora* L.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Locs. P. 375, P. 376.

Collection—U. C. Mus. Pal., Plesiotype No. 1325.

Ficus tesselata Lesquereux

(Plate 6, Fig. 2)

Ficus tesselata Lesquereux (MS.), Knowlton, U. S. Geol. Surv. Prof. Paper 101, 266, pl. 41, fig. 5, 1917.

The collections contain only 2 fairly complete specimens and several fragments of this type of leaf. These are essentially similar to the figured and type specimen of *Ficus tesselata* from the Vermejo formation. Knowlton has pointed out the resemblance to *Rhamnus salicifolius* Lesquereux,[3] from which it differs decidedly in its shape, its fewer, more acute secondaries, and its open tertiary venation. It seems even closer to *Laurus lanceolata* Knowlton from the Laramie and Dawson formations.[4] The known specimens of this species, unfortunately, are too few and too fragmentary to make possible a detailed comparison.

Knowlton has recorded *Ficus tesselata* also from the Lance formation in an unpublished manuscript at the U. S. National Museum.

I can see little justification for the reference of this species to the genus *Ficus*. In a complete survey of both eastern and western hemisphere species of *Ficus* at The New York Botanical Garden I was unable to find any leaf forms with comparable characters. The family Lauraceæ, on the other hand, contains many comparable leaf forms, chiefly in the genus *Nectandra* (cf. *N. glauca*[5] and *N. cuspidata*[6] of South America).

Occurrence—Corson Ranch, Wyoming, Loc. P. 371; Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1326.

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 139, 160, 1922.

[2] Berry, E. W., U. S. Geol. Surv. Prof. Paper 131, 16, pl. 12, fig. 7, 1923.

[3] Lesquereux, Leo, Rept. U. S. Geol. Surv. Terr., vol. 7, 282, pl. 53, figs. 9, 10, 1878; Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 154, pl. 15, fig. 4, pl. 19, fig. 2b, 1922.

[4] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 143, pl. 21, fig. 7, 1922; idem, Prof. Paper 155, 85, pl. 38, fig. 9, 1930.

[5] See sheet No. 708, Bolivia, at the Princeton University herbarium.

[6] See sheet No. 707, Mapiri, Bolivia.

Ficus coloradensis Cockerell

(Plate 6, Fig. 6)

Ficus coloradensis Cockerell, Torreya, vol. 10, 223, 1910; Knowlton, U. S. Geol. Surv. Prof. Paper 130, 134, pl. 22, fig. 1, 1922; idem, Prof. Paper 155, 69, 1930.
Ficus irregularis (Lesquereux) Lesquereux (in part), Rept. U. S. Geol. Surv. Terr., vol. 7, 196, pl. 34, figs. 4–7, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, 50, 1888; Ward, U. S. Geol. Surv., 6th Ann. Rept., 552, pl. 44, fig. 4 only, 1886; idem, Bull. 37, 38, pl. 20, fig. 4 only, 1887; Knowlton, U. S. Geol. Surv. Bull. 163, 51, 1900.
Ulmus? irregularis Lesquereux, U. S. Geol. Surv. Terr., 6th Ann. Rept. (1872), 378, 1873.

Only 4 specimens in the collections are of this type. None is completely preserved, though enough is shown to indicate similarity to the figured and type specimens of this species. There is little I can add to Knowlton's able discussion of its status.[1] It is present in the Laramie, Denver, and Medicine Bow formations, and occurs doubtfully in the Mesaverde, Hanna ("Upper Laramie" of Knowlton), and Black Buttes floras.

I can offer no suggestions regarding the botanical affinities of this leaf form.

Occurrence—Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1327.

Ficus cowanensis Knowlton

(Plate 7, Fig. 1)

Ficus cowanensis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 139, pl. 8, fig. 6, pl. 9, figs. 2, 3, 1922.

There are several incomplete specimens in the collections which are quite distinct in their large size, entire margin, obovate-lanceolate shape, extremely thick midrib, and thin, widely spaced secondaries. They agree perfectly with the description and type specimens of *Ficus cowanensis* from the Laramie formation.

This species has never been found completely preserved. I suspect that it may ultimately be found to be the same as some of the leaves usually referred to *Magnolia* or *Laurus*, as for example, *Magnolia leei* Knowlton, *M. hilgardiana* Lesquereux, or *Laurus? caudata* Knowlton.[2]

Occurrence—Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., No. 1328.

Family PLATANACEÆ

Genus CREDNERIA Zenker

Credneria protophylloides Knowlton

(Plate 8)

Credneria protophylloides Knowlton, U. S. Geol. Surv. Prof. Paper 101, 267, pl. 46, 1917.

There is a single specimen and its counterpart and many incomplete specimens from Locality P. 375 which are similar in size and essential details to the type and figured specimens of this species from the Vermejo formation. The Medicine Bow specimen is somewhat larger than the figured Vermejo specimen, but is identical with the large, unfigured specimen described by Knowlton from the same formation.

There is nothing to be added at the present time to the accurate description and discussion of this species by Knowlton. He has already adequately pointed out the superficial resemblance of this species to several American species of *Protophyllum*, and its greater similarity to a number of European members of this genus. Comparable types appear to be rare in the late Cretaceous and early Tertiary of the Rocky Mountains. Hollick has described a number of species of *Credneria* and of the related genera *Protophyllum*, *Pseudoprotophyllum*, and *Pseudoaspidiophyllum* from the Cretaceous of Alaska.[3] Most of these are represented by large leaves with the same

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 134, 1922.
[2] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 310, 313, 316, pl. 81, fig. 2, pl. 85, fig. 1, pl. 89, fig. 1, 1917.
[3] Hollick, A., U. S. Geol. Surv. Prof. Paper 159, 86–97, 1930.

distinctive venation as in *Credneria protophylloides*. With the possible exception of *C. intermedia*,[1] which is unfortunately not completely known, none of the Alaskan forms are entire-margined and they are therefore not apparently conspecific with the Medicine Bow and Vermejo species.

Among living forms, the widespread Cretaceous genus *Credneria* has apparently no closely similar leaf forms. Venation characters and general shape and size seem to indicate affinities with *Platanus*.[2]

Occurrence—Craig, Colorado, Loc. P. 375.

Collection—U. C. Mus. Pal., Plesiotype No. 1329.

Family NYCTAGINACEÆ

Genus PISONIA (Plumier) Linné

Pisonia? racemosa Lesquereux

(Plate 9, Fig. 2)

Pisonia racemosa Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 400, 1874; Rept. U. S. Geol. Surv. Terr., vol. 7, 209, pl. 35, fig. 4, 1878.

The small, delicate cluster of seed-like bodies here figured is not distinguishable from the specimens of this species from Black Buttes, Wyoming. Their exact nature is problematical and their reference to *Pisonia* is by no means definite, as Lesquereux clearly stated in his original analysis. If they are seeds they are considerably smaller and wider at the base than any seeds of *Pisonia* (= *Torrubia* Vellozo) which I have been able to find for comparison. More and better material will have to be obtained to make possible a definite systematic assignment.

Remains of this type are evidently rarely preserved, as they have not been recognized in deposits other than those at the type locality and those of the Medicine Bow formation here recorded.

Occurrence—North of Walcott, Wyoming, Loc. P. 373.

Collection—U. C. Mus. Pal., Plesiotype No. 1330.

Family LAURACEÆ

Genus CINNAMOMUM (Tournefort) Linné

Cinnamomum linifolium Knowlton

(Plate 9, Fig. 1)

Cinnamomum linifolium Knowlton, U. S. Geol. Surv. Prof. Paper 101, 319, pl. 88, figs. 3–7, 1917; idem, Prof. Paper 155, 86, pl. 59, fig. 3, 1930.

This type of leaf is rare in the collections, being represented at two localities by only three fragments, the best of which is here figured. It agrees in essentially all observable characters with the description and type specimens of this species from the lower Raton and Dawson formations of Colorado.

Knowlton has previously pointed out the general resemblance of this species to *Cinnamomum oblongatum* Berry and *C. vera* Berry from the Gulf Coast Eocene.[3] To my knowledge there are no other fossil forms known in North America with which even a general comparison can be made.

Knowlton was originally in doubt concerning the generic reference of this species. There is unquestionably a resemblance to *Cinnamomum*. I have also found leaves of essentially the same type in herbarium specimens of *Cocculus larvifolius* D.C., and *Lindera caudata* Benth., of Asia. More complete specimens will be necessary, however, before detailed comparisons can be made.

Occurrence—North of Walcott, Wyoming, Loc. P. 373.

Collection—U. S. Nat. Mus. Coll., Plesiotype No. 1331.

[1] Holliek, A., ibid., 89, pl. 55, fig. 1.
[2] Seward, A. C., Plant Life through the Ages, 404, 1933; Potonie-Gothan, Lehrbuch der Paläobotanik, 377, 1921.
[3] Berry, E. W., U. S. Geol. Surv. Prof. Paper 91, 297, pl. 79, figs. 1–8, pl. 83, fig. 6, pl. 87, fig. 4, 1916.

Cinnamomum affine Lesquereux

(Plate 9, Figs. 3, 4)

Cinnamomum affine Lesquereux (in part), Rept. U. S. Geol. Surv. Terr., vol. 7, 219, pl. 37, figs. 1–4, 7 only, 1878; Knowlton, U. S. Geol. Surv. Prof. Paper 130, 145, pl. 8, fig. 4, pl. 17, fig. 6, 1922.

The nearly complete leaf (figure 3) is the best of about a dozen of this type in the collections. It is not wholly typical. It has the tri-nerved venation diverging from a point along the midrib well above the petiole, which is so typical of *Cinnamomum affine*, yet it differs slightly in shape, which is wider and less pointed than the average of our specimens (figure 4), and in the presence of an indistinct pair of veins below the lateral primaries. These veins are not usually present in the recorded leaves of this species, though occasionally seen, as in Lesquereux's figure 7. Judging from the specimens in the Medicine Bow collections, these veins are more common than has hitherto been observed. It may be that this character is important enough to distinguish these leaves as a separate species. For the present I consider them conspecific.

This species is known at present only from the Laramie, Colgate, and Medicine Bow formations. It may possibly also occur in the Denver formation in what has been referred to *Cinnamomum* sp., for want of complete specimens.[1] A larger suite of Laramie specimens might also indicate that *C. laramiensis* Knowlton [2] is but a narrow variant of the normal *C. affine* type.

A resemblance of these fossil specimens to the leaves of the modern *Cinnamomum* cannot be denied. The subsidiary basal veins and the faintness of the tertiary venation, however, are features not observed in *Cinnamomum*.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1332, 1333.

Genus LAUROPHYLLUM Göppert

Laurophyllum meeki Dorf, n. sp.

(Plate 7, Fig. 5)

Diospyros? ficoidea Lesquereux (in part), Rept. U. S. Geol. Surv. Terr., vol. 7, 231, pl. 40, fig. 6 only, 1878.
Daphnogene elegans Watelet. Ward, U. S. Geol. Surv., 6th Ann. Rept., 553, pl. 47, fig. 4, 1886; idem, Bull. 37, 51, pl. 35, fig. 1, 1887.

There are 2 specimens which are indistinguishable from those previously referred to the above two species of Lesquereux and Ward. Their specimens were both collected from the same locality, Black Buttes, Wyoming, and are clearly the same species. The specimen here figured from the Medicine Bow formation looks, indeed, like a counterpart to the specimen figured by Ward, which is clearly not, as he himself intimates, referable to Watelet's European species. The generic reference to *Laurophyllum* is purposely non-committal, though indicating resemblance to lauraceous leaves. It is unfortunate that in all known specimens of this species the base and apex are both destroyed, making a complete description impossible.

Description—Leaves lanceolate to elliptic, narrowed gradually to the base and apex, whose specific characters are not known; length apparently about 12 to 15 cm.; width 4 to 5 cm. at the widest portion just below the middle; midrib fairly thick, straight; secondaries prominent, 6 to 8 subopposite pairs, branching acutely from the midrib at angles of 25° to 30°, curving slightly upward, converging gradually upon the leaf margins in a long series of prominent, quadrate loops; basal secondaries with prominent looping tertiaries on their lower side; remaining tertiary veins prominent, regular, and coarse, running at angles close to 90° to the midrib; margin entire, slightly undulate; texture subcoriaceous.

There do not appear to be any other described fossil forms of this genus, or related genera, with which this species can be compared.

I have named the species for Professor F. B. Meek, who collected the first specimen of this type at Black Buttes, Wyoming.

Occurrence—Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Loc. P. 376.

Collection—U. C. Mus. Pal., Plesiotype No. 1334.

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 155, 87, pl. 39, fig. 1, 1930.
[2] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 146, pl. 22, fig. 3, 1922.

Genus LAURUS (Tournefort) Linné

Laurus socialis Lesquereux?

(Plate 7, Fig. 4)

Laurus socialis Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 213, pl. 36, figs. 1–4, 7, 1878; Knowlton, U. S. Geol. Surv. Prof. Paper 101, 317, pl. 91, fig. 5, 1917; idem, Prof. Paper 155, 85, pl. 38, fig. 4, 1930.

There are only 3 fragmentary specimens of this type in the collections. They are referred with doubt to this species. The specimens are closely similar to those from the Raton and Denver formations, which seem to me, however, to differ considerably from the original type specimens from Evanston, Wyoming. In these the shape is more lanceolate and the secondaries are more numerous, more obtuse, and less prominently looped near the borders. Except for their more obtuse secondaries, the leaves of *L. socialis* are also comparable to those of *L. utahensis* Lesquereux [1] from the Raton formation. It seems probable that at least the Denver and Medicine Bow specimens should be described as a new species. In the absence of better and more numerous specimens, however, a revision and description cannot be made at the present time.

In addition to Evanston, Raton, Denver, and Dawson occurrences reported above, *Laurus socialis* is found also in the Livingston formation of Montana.[2]

Among modern leaves the lauraceous genera appear to resemble those of *Laurus socialis* most closely. Several species of *Persea* and *Laurus* with similar leaf characters have been noted. *Laurus nobilis* Linné, for example, has leaves of essentially similar shape and venation. An even closer comparison may be noted in the leaves of *Persea carolinensis* (L.) Nees.[3] A general resemblance is also apparent with leaves of *Magnolia* (Magnoliaceæ) and *Diospyros* (Ebenaceæ).

Occurrence—Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype? No. 1335.

Family TROCHODENDRACEÆ

Genus TROCHODENDROIDES Berry

Trochodendroides nebrascensis (Newberry) Dorf, n. comb.

(Plate 11, Figs. 1, 4, 6, 7)

Populus nebrascensis Newberry, New York Lyceum Nat. Hist. Annals, vol. 9, 62, 1868; Illustrations of Cretaceous and Tertiary Plants, pl. 12, figs. 4, 5, 1878; U. S. Geol. Surv. Mon. 35, 47, pl. 27, figs. 4, 5, 1898; Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, 47, 1888.
Populus arctica Heer. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, 48, 1888.
Populus crenata Unger. Lesquereux, ibid., 48.
Populus nebrascensis var. *grandidentata* Lesquereux, ibid., 47; Knowlton, U. S. Geol. Surv. Prof. Paper 155, 56, pl. 19, figs. 4–7, pl. 20, figs. 2, 6, 7, 1930.
Populus nebrascensis var. *rotundata* Lesquereux, op. cit., 47; Knowlton, op. cit., 56, pl. 20, figs. 1, 3–5, 8.
Populus nebrascensis var. *acute-dentata* Lesquereux, op. cit., 47; Knowlton, op. cit., 56, pl. 21, figs. 1, 2.
Populus nebrascensis var. *longifolia* Lesquereux, op. cit., 48; Knowlton, op. cit., 56, pl. 21, figs. 3–5.
Populus tenuinervata Lesquereux, op. cit., 48; Knowlton, op. cit., 58, pl. 22, figs. 1–4, 6.
Populus zaddachi Heer. Lesquereux, op. cit., 47; Knowlton, op. cit., 60, pl. 22, fig. 8.
Populus jacksoni Knowlton, op. cit., 58, pl. 21, figs. 6–8, pl. 22, fig. 7.
Populus zeilleri (Lesquereux) Knowlton, ibid., 54, pl. 18, fig. 8, pl. 19, figs. 1–3.
Protoficus zeilleri Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, 50, 1888.
Cissus? cannoni Knowlton, U. S. Geol. Surv. Prof. Paper 155, 113, pl. 47, fig. 5, 1930.
Cissus lesquereuxi Knowlton, ibid., 114, pl. 48, figs. 3, 4.

The imposing synonymy of this species is the continuation of the attempt to revise the status of the variable leaves usually referred to species of *Populus*. That this task is not completed is indicated in part by a recent list given to me by Dr. R. W. Brown of the U. S. Geological Survey, in which he tentatively assigns eleven additional species of the Denver flora to the above species. I have not included these species for want of complete specimens of them for comparisons.

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 318, pl. 90, fig. 4, 1917.
[2] Knowlton, F. H., U. S. Geol. Surv. Bull. 105, 56, 1893.
[3] See sheet No. 481, Biscayne Bay, Florida, at the Princeton University herbarium.

In the Medicine Bow collections there are over 30 fairly complete specimens and several fragments which could have been either segregated into about a dozen species or combined into a single species of somewhat variable leaf form. In view of the intergrading characters of these specimens and their occurrence in great numbers at one horizon of Locality P. 374, I believe it justifiable to refer them to one species. In the references given above, both Lesquereux and Knowlton have admitted that many of the species and varieties listed were difficult, if not impossible, to differentiate from the original specimens, referred at that time to *Populus nebrascensis*.

The reference of these species to the genus *Trochodendroides* rather than *Populus* is based upon the greater resemblance of the leaves to those of several trochodendraceous genera and the occurrence elsewhere of typical seeds and pods of that family in close association with the leaves of this type. Both Berry and Brown have previously presented adequate evidence for the reference to *Trochodendroides*.[1] The fossil specimens from the Medicine Bow formation resemble closely the leaves of the living *Tetracentron chinensis* Oliver [2] of eastern Asia.

The stratigraphic and geographic distribution of the various species of *Trochodendroides*, as now conceived, in the Cretaceous and Tertiary deposits of the Rocky Mountain region is still inadequately known. *Trochodendroides nebrascensis* appears to be most abundant in the lower Denver and lower Medicine Bow formations. Its reported occurrence in the Paskapoo (Fort Union?) of British Columbia [3] cannot be corroborated because of the lack of figured specimens. Moreover, the Fort Union age of the beds from which the original type specimens were collected is difficult to substantiate because of the inadequate description of the locality, which is reported by Newberry [4] as "Banks of Yellowstone River." That the species occurs in the Lance formation is indicated by U. S. National Museum specimens from the "Converse County beds" which Knowlton tentatively referred to *Populus* sp.[5] My own collection from these same beds east of Lance Creek, Wyoming, contains several leaves which are definitely referable to *Trochodendroides nebrascensis*. The species also is present in Ward's collection of leaves from Black Buttes, Wyoming, which I have consulted at the U. S. National Museum.[6]

Though somewhat variable in habit, the leaves here referred to *Trochodendroides nebrascensis* are consistent in their ovate shape, rounded or obtuse base, toothed margin, and slightly narrowed and elongate tip. In these respects they can readily be distinguished from the widespread Fort Union species, *Trochodendroides cuneata* (Newberry) Berry,[7] and from others, such as *Populus anomala* Ward, *P. cordata* Newberry, *P. craspedodroma* Ward, *P. glandulifera* Heer, *P. nervosa* Newberry, *P. newberryi* Cockerell, *P. richardsoni* Heer, and *P. speciosa* Ward, all of which are reported from the Fort Union formation. The closest resemblance among Fort Union species is with *P. daphnogenoides* Ward, which is, however, more narrowly ovate than the average leaf form of *Trochodendroides nebrascensis*. Pending the final revision of the Fort Union flora by Dr. R. W. Brown of the U. S. Geological Survey, no further attempt can be made to clarify the taxonomic allocation of the numerous leaves of this type.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Locs. P. 375, P. 376.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1336, 1337, 1338, 1339.

Family MAGNOLIACEÆ

Genus MAGNOLIA Linné

Magnolia lakesii Knowlton

(Plate 10, Fig. 2)

Magnolia lakesii Knowlton, U. S. Geol. Surv. Prof. Paper 130, 142, pl. 13, fig. 2, 1922; Brown, U. S. Geol. Surv. Prof. Paper, manuscript, 1937.

There are 8 well-preserved specimens in the collections which are referable to this species, which was originally described from the Laramie formation. As indicated above, Brown has

[1] Berry, E. W., U. S. Geol. Surv. Prof. Paper 129, 166, 1922; Canada Geol. Surv. Mem. 182, 34, 1935; Brown, R. W., U. S. Geol. Surv. Prof. Paper, manuscript, 1937; Geol. Soc. Am., Prel. Abstr., 68, Dec. 1937.

[2] See sheet No. 2156 at The New York Botanical Garden.

[3] Penhallow, D. P., Rept. Tert. Pl. Brit. Col., 78, 1908.

[4] Newberry, J. S., New York Lyceum Nat. Hist. Annals, vol. 9, 62, 1868.

[5] Knowlton, F. H., unpublished manuscript, U. S. National Museum.

[6] See specimen of *Populus* sp., No. 1149.

[7] Berry, E. W., Canada Geol. Surv. Mem. 182, 34, 1935.

recently found this species in the Colgate formation of eastern Montana. I have compared the Medicine Bow specimens with both the original type specimens and the Colgate specimens and find them all alike in essential characteristics.

The reference to the genus *Magnolia* may be correct, though as yet unsubstantiated by associated seeds, flowers, or wood. I have seen no modern leaves closely resembling these specimens.

Occurrence—Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1340.

Magnolia dakotana Berry

(Plate 10, Fig. 3)

Magnolia dakotana Berry, U. S. Geol. Surv. Prof. Paper 185-F, 130, pl. 25, figs. 6, 7, 1934.

There are 6 specimens of this type, of which the best is figured. Except for the slight abnormality in the basal venation of the figured type, it is difficult to differentiate between the Lance and Medicine Bow specimens. Despite the well-defined characters of this species, there appear to be no other fossil forms with which a comparison can be made. Berry's reference to the genus *Magnolia* was made with some hesitation. At present it seems desirable to retain it there pending further studies.

Occurrence—North of Walcott, Wyoming, Loc. P. 373; ?Corson Ranch, Wyoming, Loc. P. 371.

Collection—U. C. Mus. Pal., Plesiotype No. 1341.

Magnolia nervosa (Knowlton) Brown

(Plate 10, Fig. 4)

Magnolia nervosa (Knowlton) Brown, U. S. Geol. Surv. Prof. Paper, manuscript, 1937.
Pterospermites nervosus Knowlton, U. S. Geol. Surv. Prof. Paper 101, 273, pl. 48, fig. 4, 1917.

This type of leaf is rare in the Medicine Bow collections, being represented only by a few fragments and the single fairly complete leaf figured. This specimen is identical with those from the Colgate and lower Lance formations of eastern Montana which are in the collections of the U. S. National Museum. Brown has referred these to *Magnolia nervosa*, with which he has synonymized the specimen of *Pterospermites nervosus* from the Vermejo formation.

Occurrence—Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1342.

Magnolia pulchra Ward

(Plate 11, Fig. 8)

Magnolia pulchra Ward, U. S. Geol. Surv., 6th Ann. Rept., 556, pl. 60, figs. 2, 3, 1886; idem, Bull. 37, 103, pl. 48, figs. 3, 4, 1887.

This species is represented only by several fragmentary leaves and the nearly complete specimen figured. It is identical in all respects with the type and figured specimen of *Magnolia pulchra*, except possibly for the tip, which is turned under in the Medicine Bow specimen but appears to be slightly more obtuse. The obovate shape and thin secondaries clearly distinguish this species from the others referred to the same genus.

The original specimens of this species are from the Mesaverde formation. Berry has recently reported it from the upper Ravenscrag (Fort Union) of southern Saskatchewan.[1] I have not been able to see his specimens for comparison, so cannot comment on their relationship to the late Cretaceous specimens.

The generic reference to *Magnolia* seems reasonable. I have noted also a resemblance of the specimens to the leaves of *Asimina triloba* Dunal (Anonaceæ), which are identical in shape and size and differ only slightly in their more regular secondary veins.

Occurrence—Corson Ranch, Wyoming, Loc. P. 371; Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1343.

[1] Berry, E. W., Canada Geol. Surv. Mem. 182, 35, 1935.

Genus MAGNOLIOPHYLLUM Conwentz

Magnoliophyllum cordatum Dorf, n. sp.

(Plate 9, Fig. 5; Plate 10, Fig. 1)

This type of leaf is fairly abundant, although its large size has made it impossible to procure complete specimens. The figured specimen is the most nearly complete of over 80 specimens collected in the field.

Description.—Leaves cordate to broadly ovate, symmetrical, with the base cordate to truncate and the tip acute; length ranging from 10 to 18 cm., width from 8 to 16 cm., petiole stout and up to 2.5 cm. long; midrib very stout; secondaries well defined, ten to twelve pairs mostly alternate, leaving the midrib at angles varying from slightly more than 90° near the base, to 60° at the middle, and to 50° or less near the tip; basal secondaries only slightly arched upward, upper secondaries arching upward more abruptly, producing a greater distance between the secondaries near the margins than at the midrib; one to three prominent tertiaries branching from lower sides of secondaries forming conspicuous loops with superjacent tertiaries or secondaries close to the margins; remaining tertiaries strong, percurrent, forming a coarse network in the intersecondary spaces; margin mainly entire, occasionally undulate in the upper half of large leaves; texture firm.

It seems strange that this well-defined type of leaf has apparently not been encountered previously in the late Cretaceous deposits of North America. I believe, however, that it is closely related to the specimens from the Raton formation which Knowlton referred to *Magnolia cordifolia* Lesquereux.[1] There are notable differences, however, chiefly in the character of the base, the upper secondaries, and the number and prominence of the marginal loops, all of which are consistently the same in *Magnoliophyllum cordatum.*

I have not been able to determine the taxonomic affinities of this species, although its characters are strongly suggestive of the family Magnoliaceæ. The smaller leaves of the living *Magnolia dealbata* Zucc. of Mexico and the larger leaves of *M. acuminata* Linné of southeastern United States [2] are of the same size and have almost identical venation and basal characters. I have found no other modern leaves which are so nearly identical, so do not hesitate in referring the species to *Magnoliophyllum,* implying relationship to the family Magnoliaceæ.

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Loc. P. 375.

Collection—U. C. Mus. Pal., Cotypes Nos. 1344, 1345.

FAMILY LEGUMINOSÆ

Genus LEGUMINOSITES Bowerbank

Leguminosites arachioides minor Berry

(Plate 11, Figs. 2, 3, 5)

Leguminosites arachioides minor Berry, U. S. Geol. Surv. Prof. Paper 156, 89, pl. 14, figs. 2–6, 1930; Canada Geol. Surv. Mem. 182, 64, 1935.
Leguminosites? arachioides (Lesquereux) Lesquereux. Penhallow, Rept. Tert. Pl. Brit. Col., 61, fig. 14, 1908.
Nyssa (?) racemosa Knowlton, U. S. Geol. Surv. Bull. 152, 153, 1898; idem, Prof. Paper 134, 95, 1924.
Berrya racemosa Knowlton, U. S. Geol. Surv. Prof. Paper 155, 134, pl. 41, figs. 4–5, 1930.
Sabalites fructifer Lesquereux (in part), Rept. U. S. Geol. Surv. Terr., vol. 7, 114, pl. 11, figs. 3 (fruits at base of figure only), 3a, 1878.

This type of seed is represented in the collections by a compound raceme and its counterpart and several detached fruits.

Berry described specimens from the Wilcox formation as the variety *minor* of the well-known and widespread *Leguminosites? arachioides* (Lesquereux) Lesquereux, on the basis of their smaller size. The Medicine Bow specimens appear to be slightly smaller still, though of the same size exactly as several detached fruits from the Wilcox and Denver. In every other respect our specimens are identical with the type and figured specimens from the Wilcox, the Raton, and the Denver formations. The species is also recorded from the Animas, Dawson, and Black Buttes floras.

[1] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 315, pl. 86, pl. 89, fig. 1, 1917.
[2] See sheet No. 13, Princeton University herbarium.

The systematic status of this type of seed is still unsettled. Lesquereux regarded it as a palm, and Knowlton was inclined toward *Nyssa*, though he later reconsidered and gave it the noncommittal name *Berrya*, apparently unaware that this name was preoccupied and that Berry was at that precise time describing the same type of seed from the Wilcox beds as *Leguminosites arachioides minor*, implying leguminous affinities. Quite recently Brown [1] has pointed out the trochodendraceous character of the fossil specimens and their usual association, as in the Medicine Bow formation, with leaves referred to *Trochodendroides*.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1346, 1347, 1348.

FAMILY ANACARDIACEÆ

Genus PISTACIA Linné

Pistacia eriensis Knowlton

(Plate 19, Fig. 7)

Pistacia eriensis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 150, pl. 28, figs. 1–4, 1922.
Pistacia hollicki Knowlton, ibid., 151, pl. 28, figs. 5, 6.

There are 4 leaves with attached leaflets and 3 detached leaflets which are indistinguishable from the Laramie specimens referred to *Pistacia eriensis*. Two of the specimens, one of which is figured, are somewhat larger than any of the Laramie specimens but are otherwise similar.

In view of the very slight differences in size and arrangement between *Pistacia eriensis* and *P. hollicki*, and the fact that the specimens all come from one locality, there seem to be no grounds for maintaining two distinct species. Knowlton referred to them as "obviously related and possibly identical." [2] No other fossil forms appear to be comparable, although the large leaves from the same Laramie locality which Knowlton described as *Juglans newberryi* [3] might ultimately prove to be variants of *Pistacia eriensis*, since their shape and venation are remarkably similar.

Knowlton referred this species to the genus *Pistacia* with considerable certainty, on the basis of similar arrangement, shape, and venation to *Pistacia lentiscus* Linné and *P. mutica* Frick and Meyer of Southern Europe. The resemblance is indeed close, although equally good comparisons can be made with species of *Rhus*, belonging to the same family, and with *Juglans* of the Juglandaceæ. In the absence of conclusive evidence, however, it does not seem desirable to make any change in the name at the present time.

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372; north of Walcott, Wyoming, Loc. P. 373.

Collection—U. C. Mus. Pal., Plesiotype No. 1349.

Family CELASTRACEÆ

Genus CELASTRUS Linné

Celastrus taurinensis Ward

(Plate 12, Figs. 1, 2, 3)

Celastrus taurinensis Ward, U. S. Geol. Surv., 6th Ann. Rept., 555, pl. 52, figs. 15, 16, 1886; idem, Bull. 37, 79, pl. 34, figs. 5, 6, 1887; Hollick, Geol. Surv. Louisiana, Spec. Rept. No. 5, 285, pl. 46, fig. 1, 1899; Knowlton, Washington Acad. Sci. Proc., vol. 11, 213, 1909; Berry, U. S. Geol. Surv. Prof. Paper 91, 267, pl. 60, figs. 1–3, 1916; Canada Geol. Surv. Mem. 182, 42, 1935.
Celastrus ovatus Ward, U. S. Geol. Surv., 6th Ann. Rept., 555, pl. 53, fig. 7, 1886; idem, Bull. 37, 81, pl. 36, fig. 1, 1887.
Celastrus wardii Knowlton and Cockerell, U. S. Geol. Surv. Bull. 696, 160, 1919.
Celastrus curvinervis Ward, U. S. Geol. Surv., 6th Ann. Rept., 555, pl. 53, figs. 9, 10, 1886; idem, Bull. 37, 82, pl. 36, figs. 3, 4, 1887.
Aralia taurinensis (Ward) Sanborn, Carnegie Inst. Wash. Pub. No. 465, 27, pl. 10, figs. 1, 2, 4, 1935.

The collections contain 5 well-preserved and fairly complete specimens which are similar in every essential detail to the type and figured specimens of *Celastrus wardii* (= *Celastrus ovatus*) and *C. curvinervis*. Berry has recently [4] synonymized both of these species with *Celastrus tauri-*

[1] Brown, R. W., Geol. Soc. Am., Prel. Abstr., 68, Dec. 1937.
[2] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 151, 1922.
[3] Knowlton, F. H., ibid., 120, pl. 20, figs. 8–10.
[4] Berry, E. W., Canada Geol. Surv. Mem. 182, 42, 1935.

nensis, which Sanborn, at about the same date,[1] considered more appropriately referred to the genus *Aralia*. It seems to me that the species might equally well be a *Viburnum*. In my private herbarium I have a number of leaves of the Asiatic *Viburnum seiboldii?*, whose characters, particularly of venation and marginal teeth, appear to be more like those of the fossil specimens than are those of any *Aralia*. In the range of size and shape variations, moreover, these *Viburnum* leaves can exactly match the variations seen in the leaves of *Celastrus taurinensis* and its synonymous forms. In view of the scarcity of leaves of this type in the Medicine Bow collections, however, it does not seem desirable to make further changes in the taxonomy, but rather await the revision of the Fort Union flora by Dr. Roland W. Brown, who has a large suite of specimens of this species at his disposal at the U. S. National Museum.

This species is evidently widespread and of long geologic range in North America. In addition to its recorded occurrences, there are also several perfect specimens of it in the unclassified material from Black Buttes, Wyoming, which I have consulted at the U. S. National Museum. It is one of the few Medicine Bow species which ranges up into the Fort Union of the Rocky Mountain region. As seen in the citations above, it is also common in the Eocene of the Gulf Coast and of Oregon. Any attempt to separate the late Cretaceous forms from those of the Paleocene and Eocene on justifiable grounds has been futile, although the Cretaceous specimens do seem to be more lanceolate in average shape. Whether or not this character can become the basis for specific separation remains to be seen in subsequent studies.

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1350, 1351, 1352.

Family RHAMNACEÆ

Genus RHAMNUS Linné

Rhamnus salicifolius Lesquereux

(Plate 12, Figs. 4, 5; Plate 13, Fig. 4)

Rhamnus salicifolius Lesquereux, Am. Jour. Sci., 2d ser., vol. 45, 206, 1868; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1869), 196 (reprint, 1873); Rept. U. S. Geol. Surv. Terr., vol. 7, 282, pl. 53, figs. 9, 10, 1878; Knowlton, U. S. Geol. Surv. Prof. Paper 101, 271, 1917; idem, Prof. Paper 130, 154, pl. 15, fig. 4, pl. 19, fig. 2b, 1922.

Rhamnus salicifolius Lesquereux?. Knowlton, U. S. Geol. Surv. Bull. 163, 70, 1900; idem, Prof. Paper 155, 107, pl. 46, fig. 12, 1930.

Rhamnus belmontensis Knowlton and Cockerell, U. S. Geol. Surv. Bull. 696, 544, 1919; Knowlton, U. S. Geol. Surv. Prof. Paper 130, 155, 1922.

Rhamnus elegans Newberry, New York Lyc. Nat. Hist. Annals, vol. 9, 49, 1868; U. S. Geol. Surv. Mon. 35, 117, pl. 50, fig. 2, 1898.

Juglans laramiensis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 120, pl. 20, fig. 12, 1922.

Ficus? smithsoniana? (Lesquereux) Lesquereux. Knowlton, ibid., 130, pl. 21, fig. 4.

Lanceolate leaves, referable to *Rhamnus salicifolius*, are abundant and widespread in the Medicine Bow formation. More than 20 well-preserved specimens in the collections indicate considerable variation in size, yet are identical in secondary and tertiary venation and general shape. The average characteristics are precisely as shown in Lesquereux's original figures,[2] except that the reconstruction of the broken tip of his figure 9 should apparently have been considerably elongated. In view of the intergrading variations observed in the Medicine Bow specimens, it is evident that the species listed above as synonymous are merely slight variants of the average leaf form of *Rhamnus salicifolius*. It seems desirable to re-describe this species on the basis of the abundant material collected.

Description (*Supplementary*)—Leaves typically narrowly lanceolate, narrowing gradually from below the middle to an elongate acute tip, and more abruptly below to an equilateral or slightly inequilateral cuneate base; length 5 to 12 cm., width 1.5 to 2.5 cm., average dimensions apparently about 10 by 2 cm., petiole short, thin, up to 1 cm. long; midrib firm, relatively straight; 10 to 14 pairs of thin, mainly alternate secondaries leaving the midrib at angles of 25° to 45°, curving uniformly upward toward the margins, converging, unbranched, paralleling margins and

[1] Sanborn, Ethel I., Carnegie Inst. Wash. Pub. No. 465, 27, 1935.

[2] Lesquereux, Leo, Rept. U. S. Geol. Surv. Terr., vol. 7, pl. 53, figs. 9, 10, 1878.

becoming indistinct close to the leaf borders; tertiaries thin, percurrent at angles approaching 90° to the plane of the midrib; finer nervation not preserved; margin entire throughout; texture firm.

This species appears to be most abundant in the Laramie and Medicine Bow formations. It is evidently less abundant though definitely present in the Vermejo and Black Buttes floras, and is questionably identified in the Denver and Dawson floras. Its reported occurrence in the Lance formation [1] seems likely, though as yet unsubstantiated by figured specimens. To my knowledge there are no reported occurrences of leaves of this type from formations of indisputable Paleocene or later age.

The leaves of this fossil species are, in my opinion, distinctly not rhamnaceous. I have studied all available herbarium material of the genera of the Rhamnaceæ at The New York Botanical Garden and failed to find a comparable leaf type. Several genera of the Lauraceæ, on the other hand, are very similar in most details. *Persea lanceolata* has leaves of the same general shape and venation. Even closer are the leaves of *Nectandra pichurim* (H.B.K.) Mez.,[2] of northern South America, and *N. membranacea* (S.W.) Griesb.,[3] of Central America, which possess the same well-defined secondary and tertiary venation and the same variations in size and shape as the fossil specimens.

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Loc. P. 376.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1353, 1354, 1355.

Rhamnus cleburni Lesquereux

(Plate 14, Figs. 5, 6)

Rhamnus cleburni Lesquereux, U. S. Geol. Surv. Terr., 6th Ann. Rept. (1872), 381, 400, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 280, pl. 53, figs. 1–3, 1878; Berry, U. S. Geol. Surv. Prof. Paper 91, 283, 1916; Knowlton, U. S. Geol. Surv. Prof. Paper 101, 332, pl. 113, fig. 3, 1917; idem, Prof. Paper 155, 104, only pl. 46, figs. 10, 11, 1930.

Rhamnus rectinervis Heer (in part). Lesquereux, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1871), 295, 298; idem (1872), 382, 397, 402, 1873; idem (1873), 405, 1874; Rept. U. S. Geol. Surv. Terr., vol. 7, 278, pl. 52, fig. 15 only, 1878.

Rhamnus brittoni Knowlton, U. S. Geol. Surv. Prof. Paper 130, 156, pl. 15, fig. 6, pl. 24, fig. 8, 1922.

This type of leaf is one of the more abundant and widespread in the Medicine Bow collections. It is remarkably consistent in the majority of its observable characters, being particularly so in its secondary and tertiary venation. The average leaf specimen is identical with the original type specimens of *Rhamnus cleburni* from the Denver formation. In studying the large number of leaves of this type in my collection, however, it has become apparent that the leaves are somewhat more variable, as one would expect, than Lesquereux's description and figures might imply. The two specimens here figured were chosen to show such variations rather than the average type. In figure 5, for example, is shown a somewhat more lanceolate leaf than the average, whose upper margin is invested with short, blunt, upward-pointing teeth, identical with those seen in Lesquereux's figure of *Rhamnus rectinervis*. The largest specimen obtained is shown in figure 6. This is somewhat wider above the middle than the average form, and has a more elongate tip; otherwise it is precisely the same. In view of the range of variations now known it seems desirable to redescribe the species as here conceived.

Description (Supplementary)—Leaves oval or elliptic, more rarely lanceolate, the slightly unequal base narrowly to broadly cuneate, rarely rounded, and the apex acute or slightly extended into an acuminate tip; average dimensions about 11 cm. by 4.5 cm., ranging up to 17 cm. by 9 cm.; minimum size observed in collections 7 cm. by 4 cm.; petiole stout, relatively long, up to 3 cm.; midrib straight, heavy except near the apex where it becomes thin and occasionally undulating; 9 to 15 pairs of prominent secondaries, subopposite to alternate, leaving the midrib at angles consistently from 40° to 45° except near the apex where they become more acute; rarely the basal pair are slightly less acute; secondaries closely and evenly set along the midrib, becoming more

[1] Hollick, A., in Brown, B., Am. Mus. Nat. Hist. Bull., vol. 23, 823–845, 1907; Knowlton, F. H., Washington Acad. Sci. Proc., vol. 11, 185, 1909.

[2] See sheets No. 1396 and No. 4323, New York Botanical Garden.

[3] See sheets No. 987 and No. 169, New York Botanical Garden.

remote near the apex, consistently parallel, curving only slightly toward the margins where they curve upward more abruptly and run into the margins; secondaries near apex paralleling and curving in toward the midrib; tertiaries fine and very closely spaced, flexuose percurrent, at approximately right angles to the secondaries; very rarely, tertiary branches given off from the lower sides of the secondaries near the margins; finer nervation not observable; margin usually entire, slightly undulate, more rarely with blunt, inconspicuous, upward-pointing teeth near the apex; texture firm.

The characters of this type of leaf are so easily recognized and consistent that I feel no hesitancy in referring *Rhamnus brittoni* and one specimen of *R. rectinervis* to the same species. I was at first also inclined to include in it the specimens referred to *R. goldianus*,[1] but find that in none of my specimens is there any trace of the well-developed branching of the lower secondaries found in that species. Knowlton has remarked upon the similarity of certain specimens from the Denver flora referred to *Berchemia multinervis* (Al. Braun) Heer.[2] These are, however, of different shape and do not possess the characteristic upper secondaries paralleling and curving in toward the midrib. In the same report, Knowlton included in *Rhamnus cleburni* the specimens which Lesquereux had referred to *Cornus studeri* Heer?. These differ, however, in their more remote, converging secondaries, which are usually forked near the leaf margins.

As previously recorded, *Rhamnus cleburni* and the species here included in it are known from the Laramie, Denver, Dawson, Raton, and Black Buttes floras of the Rocky Mountain region. It is also present in collections from the Lance of "Converse County," Wyoming, both at Princeton University and the U. S. National Museum. It is not known to occur in the Fort Union floras of western North America, but is reported, though unfortunately not figured, from the Eocene of Oregon [3] and the Gulf Coast.[4] Berry has pointed out "the similarity and possible identity" of the Gulf Coast specimens to the variable leaves of *Rhamnus coushatta* Berry.[5] It is in any event apparent that both the Gulf and West Coast Eocene species are closely related to the late Cretaceous *R. cleburni*, indicating a survival of descendant forms in regions outside the Rocky Mountain area.

It is difficult to see any resemblance between the fossil leaves of *Rhamnus cleburni* and the leaves of modern species of *Rhamnus*. In my opinion, after consulting herbarium specimens at The New York Botanical Garden, the fossil specimens are not referable to any living genus of the family Rhamnaceæ. On the other hand, their leaf characters are closely similar to several genera of the family Dilleniaceæ, namely *Davilla*, *Dillenia*, *Doliocarpus*, and *Tetracera*. In *Dillenia* and *Tetracera* the leaves are usually more regularly toothed along the whole margin than in the fossil specimens. The leaves of *Doliocarpus dentatus* (Aubl.) Standley [6] of Central and South America are practically indistinguishable in all details from the fossil specimens. Almost equally comparable are the leaves of *Davilla multiflora* St. Hil.,[7] which differ only in their slightly more obtuse secondaries. Other genera which were consulted but eliminated because of marked differences were *Rhamnidium* (Rhamnaceæ), *Cuphea* (Lythraceæ) and *Meliosma* (Sabiaceæ).

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Loc. P. 376.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1356, 1357.

Genus ZIZYPHUS Adanson

Zizyphus hendersoni Knowlton

(Plate 12, Fig. 6)

Zizyphus hendersoni Knowlton, U. S. Geol. Surv. Prof. Paper 130, 157, pl. 15, figs. 1, 2, 1922.
Zizyphus coloradensis Knowlton, ibid., 157, pl. 15, fig. 5.

There are 5 specimens in the collections which were at first thought referable to *Ficus planicostata*, but which are consistently different in their thinner texture and the presence of 5

[1] Lesquereux, Leo, Rept. U. S. Geol. Surv. Terr., vol. 7, 281, pl. 53, figs. 4–8, 1878; Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 332, pl. 101, fig. 4, pl. 112, fig. 5, 1917.
[2] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 155, 104, 1930.
[3] Knowlton, F. H., U. S. Geol. Surv. Bull. 204, 80, 1902.
[4] Berry, E. W., U. S. Geol. Surv. Prof. Paper 91, 283, 1916.
[5] Berry, E. W., U. S. Geol. Surv. Prof. Paper 131, 15, 1923.
[6] See sheet No. 3748 at The New York Botanical Garden.
[7] See sheet No. 5359.

rather than 3 basal primaries. They cannot be distinguished from the Laramie specimens which Knowlton called *Zizyphus hendersoni*. The specimen of *Z. coloradensis*, which I have examined at the U. S. National Museum, is clearly the same species, since it does not show any trace of upper marginal teeth, as Knowlton suspected.

This species is at present known only from the Laramie and Medicine Bow formations.

I have been unable to find any modern leaves with which this species can be compared.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1358.

Family VITACEÆ

Genus CISSITES Heer

Cissites lobatus Dorf, n. sp.

(Plate 13, Figs. 2, 3)

In the field collections there were 27 specimens of this type, which were consistent in shape, average size, and venation. Four of the better specimens were retained for study.

Description—Leaves oval to elliptic, widest just below the middle, obtusely wedge-shaped at the base, and gradually narrowed to a slightly elongate, acuminate tip; length 6 to 9 cm.; width 3 to 5 cm.; petiole at least 1.2 cm. long; secondaries tri-nerved from just below the base of the blade, the laterals almost as heavy as the midrib, and given off at an angle of 20°; next pair of secondaries branching from the midrib just below the middle; these and the widely spaced secondaries above are acute, slightly curved upward, and forking toward the margin forming loops with the secondaries or their branches above; 3 to 4 prominent forking tertiaries along the lower edge of the lateral basal secondaries, and usually one tertiary well developed from the upper edges; margin entire, palmately lobed by 2 pairs of shallow, narrow, rounded sinuses; central lobe largest, symmetrically oval; lateral lobes smaller and asymmetrical; texture subcoriaceous.

This species shows only a general resemblance to other fossil species of *Cissites* from North America. The closest similarity is with *C. colgatensis* Brown, which, however, is uniformly smaller, more distinctly lobed, and of an entirely different shape.[1] The resemblance to *C. panduratus* Knowlton from the Vermejo formation is also apparent though more remote.[2] It is, however, similar to specimens from the Lance of "Converse County," Wyoming, which Knowlton tentatively called *Ficus? lobata* Knowlton in an unpublished manuscript at the U. S. National Museum.

In the attempt to determine the probable botanical affinities of this type of leaf I have surveyed all available herbarium material at The New York Botanical Garden of the following families: Araliaceæ, Magnoliaceæ, Moraceæ, Sterculiaceæ, and Vitaceæ. The practice of referring leaves of this general form to *Cissites*, implying relationship to the genus *Cissus* (Vitaceæ), is in a measure substantiated by the leaf characters of several living species of that genus, notably *C. rhombifolia* (sheet No. 557). A general resemblance was also seen to the variable leaves of *Pterospermum proteus* Burkill (sheet No. 10120) of the Sterculiaceæ. No exact duplicate of the fossil specimens has yet been seen in any of the families studied.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372.

Collection—U. C. Mus. Pal., Type No. 1359, Paratype No. 1360.

Genus VITIS (Tournefort) Linné

Vitis stantoni (Knowlton) Brown

(Plate 17, Fig. 1)

Vitis stantoni (Knowlton) Brown, U. S. Geol. Surv. Prof. Paper, manuscript, 1937.
Castalia stantoni Knowlton, U. S. Geol. Surv. Bull. 257, 147, pl. 19, fig. 4, 1905.
Viburnum vulpinum Knowlton, U. S. Geol. Surv. Prof. Paper 98, 92, pl. 18, fig. 1, 1917.
Vitis dakotana Berry, U. S. Geol. Surv. Prof. Paper 185-F, 130, pl. 26, figs. 4–6, pl. 27, 1934.

There are two specimens from Locality P. 374 which appear to be referable to this species, which Brown has recently synonymized as given above. As now known this species occurs in

[1] Brown, R. W., U. S. Geol. Surv. Prof. Paper, manuscript, 1937.
[2] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 274, pl. 49, fig. 10, 1917.

the Judith River (?), Fox Hills, Colgate, Lance, and Medicine Bow floras. It is apparently most abundant in the lower Lance formation, from which I have collected a considerable number of perfect specimens near Lance Creek, Wyoming, and near Buffalo, South Dakota.

The reference to the genus *Vitis* seems reasonable though as yet not corroborated by associated seeds, flowers, or wood.

Occurrence—Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1361.

Family TILIACEÆ

Genus APEIBOPSIS Heer

Apeibopsis? laramiensis Knowlton

(Plate 14, Fig. 1)

Apeibopsis? laramiensis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 159, pl. 7, fig. 4, 1922.

There are 2 well-preserved, incomplete specimens from Locality P. 374 which are similar except for their somewhat smaller size to the type and figured specimens of this species from the Laramie formation. Its very truncate base, thick midrib, and thin, closely spaced, widely divergent secondaries are easily recognizable and diagnostic.

The generic reference has been justifiably questioned by Knowlton. Until more complete specimens are found, however, it is difficult to attempt a taxonomic revision.

Occurrence—Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1362.

Genus GREWIOPSIS Saporta

Grewiopsis saportana Lesquereux

(Plate 13, Figs. 1, 5, 6)

Grewiopsis saportana Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 257, pl. 50, figs. 10–12, 1878; Brown, U. S. Geol. Surv. Prof. Paper, manuscript, 1937.

Aleurites eocenica Lesquereux, U. S. Geol. Surv. Terr., 6th Ann. Rept. (1872), 397, 1873.

Grewiopsis ficifolia Ward, U. S. Geol. Surv., 6th Ann. Rept., 556, pl. 46, figs. 1, 2, 1886; idem, Bull. 37, 92, pl. 41, figs. 1, 2, 1887.

Grewiopsis eocenica (Lesquereux) Knowlton, U. S. Geol. Surv. Bull. 152, 114, 1898; Washington Acad. Sci. Proc., vol. 11, 207, 1909.

This type of leaf is by far the most abundant at Locality P. 374. Over 25 well-preserved specimens were collected for study. The majority of these cannot be distinguished in any essential detail from the type specimens from Black Buttes, Wyoming. These were originally described as *Aleurites eocenica* by Lesquereux, who subsequently changed the name to *Grewiopsis saportana*. In a later report Knowlton changed the name again to *Grewiopsis eocenica*, a procedure which hardly seems justified, as has been pointed out by Brown. Knowlton also included Ward's specimens of *Grewiopsis ficifolia* in this species, a reference clearly substantiated by the numerous Medicine Bow specimens. In view of the large number of variants now available it seems appropriate to re-describe the species.

Description (*Supplementary*)—Leaves elliptic-lanceolate to ovate, narrowing gradually to a blunt, obtuse point and more abruptly to a symmetrical, cuneate base; length 4.5 to 9.5 cm.; width 2.2 to 6.5 cm., widest below the middle; average dimensions apparently about 7.5 by 4.5 cm.; petiole relatively thin, very long, up to 5 cm.; midrib heavy except near apex, fairly straight; 6 to 9 pairs of secondaries, mainly alternate, pinnate, approaching palmateness in basal pair, leaving midrib at angles of about 30° near apex to as high as 60° near base; venation craspedodrome, the secondaries irregularly curved toward the margins where they usually branch into the marginal teeth, these branches being more numerous in lower secondaries; tertiary venation distinct, uniform, the veins continuous or branched at angles approaching 90° to the secondaries; margin finely serrate or denticulate, often inconspicuously; the teeth short, irregular in size, and usually closely spaced; texture subcoriaceous.

This species is apparently most abundant in the Black Buttes and Medicine Bow floras. Its reported occurrence in the Lance formation of eastern Wyoming by Knowlton [1] has been amply substantiated by his unpublished manuscript and figures at the U. S. National Museum. In the summer of 1936, I visited this region and collected several complete specimens clearly belonging to this same species. Brown has also collected excellent specimens of it in the Hell Creek member of the Lance near Marmarth, North Dakota. There do not appear to be any other reported occurrences of the species in North America, although Chaney reports that *Callichlamys zeteki* from the upper Eocene (?) of Oregon [2] is of the same general type.

Except for their resemblance to leaves of the living genus *Callichlamys*, as pointed out by Chaney, I have found no other forms except *Grewiopsis* with which the fossil leaves can be compared.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1363, 1364, 1365.

Family CORNACEÆ

Genus CORNOPHYLLUM Newberry

Cornophyllum wardii Dorf, n. sp.

(Plate 16, Fig. 3)

Cornus studeri? Heer. Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 244, pl. 42, figs. 4, 5, 1878; Ward, U. S. Geol. Surv., 6th Ann. Rept., 553, pl. 48, fig. 1, 1886; idem, Bull. 37, 55, pl. 26, fig. 1, 1887; Knowlton, U. S. Geol. Surv. Bull. 163, 68, pl. 15, fig. 3, 1900; idem, Prof. Paper 101, 342, pl. 109, fig. 2, 1917; idem, Prof. Paper 155, 104, only pl. 40, fig. 6, 1930.

The single, nearly complete specimen figured is one of 6 well-preserved specimens of this type of leaf. It is impossible to distinguish from the Mesaverde specimen referred by Ward to the European species *Cornus studeri*. Knowlton has reviewed in detail the status of the various specimens which have been referred to this species, referring several to *Rhamnus cleburni* Lesquereux.[3] He adds, however, that Ward's Mesaverde specimen and his own specimens from the same formation are not referable to *Rhamnus cleburni* nor are they similar to the European *Cornus studeri*. With the additional material now at hand it seems advisable to describe the species as new, despite the indefinite generic reference.

Description—Leaves narrowly ovate to elliptic, gradually narrowed to an extended, slightly acuminate or acute tip, and more abruptly below to a widely cuneate base; length 7 to 13 cm., width 4 to 7 cm., widest below the middle, midrib very thick below, thinning gradually to the apex; petiole thick, up to 1.5 cm. long, secondary venation pinnate, mainly alternate, camptodrome; secondaries more widely spaced along midrib and more abruptly curved upward in upper half than in lower half of leaf, outer ends of secondaries tending to parallel margins for considerable distance, looping indistinctly with tertiary branches of secondaries next above; tertiary venation indistinct, nervilles running mainly at high angle to midrib; margin entire; texture coriaceous.

This species is of the general type of *Rhamnus cleburni*, though clearly distinguishable by the more widely spaced, less numerous secondaries, which do not even approach the type of parallel venation of *R. cleburni*. There are also discernible differences in tertiary venation and general shape. It seems evident, therefore, that Lesquereux's Denver specimens of *Cornus studeri?* which Knowlton identified as *Rhamnus cleburni* belong rather to the type here called *Cornophyllum wardii*. Also, one of Knowlton's specimens of *Rhamnus cleburni* from the Denver flora (plate 40, figure 6) is clearly referable to *Cornophyllum wardii*.

In addition to the Medicine Bow occurrences, and its presence in the Mesaverde, Raton, and Denver formations, this species is also present in my collections of Lance material obtained in 1936 from two localities east and northeast of Lance Creek, Wyoming.

The general shape, entire margin, and secondary venation of this species resemble the leaves of the living species of *Cornus*, to which the previously recorded specimens were referred by

[1] Knowlton, F. H., Washington Acad. Sci. Proc., vol. 11, 207, 1909.
[2] Chaney, R. W., Carnegie Inst. Wash. Pub. No. 439, 95, 1933.
[3] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 155, 105, 1930.

Lesquereux, Ward, and Knowlton. I am following the practice of Newberry and Berry in applying the less positive name *Cornophyllum* to the specimens. In addition to a resemblance to leaves of *Cornus*, the fossil leaves are also comparable in general form and venation to *Rhamnidium* (Rhamnaceæ), *Berchemia* (Rhamnaceæ) and *Premna* (Verbenaceæ).

Occurrence—Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Loc. P. 376.

Collection—U. C. Mus. Pal., Type No. 1366.

Family BIGNONIACEÆ

Genus DOMBEYOPSIS Unger

Dombeyopsis obtusa Lesquereux

(Plate 15, Figs. 1, 2)

Dombeyopsis obtusa Lesquereux, U. S. Geol. Surv. Terr., 6th Ann. Rept. (1872), 375, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 255, pl. 47, figs. 4, 5, 1878; Knowlton, U. S. Geol. Surv. Prof. Paper 130, 162, pl. 13, fig. 4, pl. 20, fig. 11, pl. 27, figs. 1–4, 1922; idem, Prof. Paper 155, 124, 1930.
Phyllites populoides Knowlton, U. S. Geol. Surv. Prof. Paper 101, 280, pl. 50, figs. 1, 2, 1917.
Populus? neomexicana Knowlton, ibid., 258, pl. 53, fig. 3.
Phyllites trinervis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 166, pl. 24, fig. 12, 1922.

There are four nearly complete specimens in the collections which resemble one or another of the somewhat variable leaves previously referred to this species. Of the specimens here shown, figure 1 resembles more closely the numerous specimens from the Laramie formation, including Lesquereux's type specimen shown in volume 7, plate 47, figure 5. The other Medicine Bow specimen, figure 2, is more of the type of Lesquereux's figure 4, and is clearly the same species as the Vermejo specimens referred to *Phyllites populoides* and *Populus? neomexicana*. Knowlton's discussions of *Dombeyopsis obtusa* in the reports cited above have adequately treated its taxonomic relationships and its variability. It may be added here that the apex of the leaf may be slightly emarginate, as shown in both my specimens.

This species is now known from the Laramie, Trinidad, Vermejo, lower Denver, Dawson, and lower Medicine Bow formations, and is not known from beds of indisputable Paleocene or later age.

I have found no modern leaves closely resembling those of this species. Analogous types are met with in the genera *Ficus* (Moraceæ) and *Cocculus* (Menispermaceæ), but these are not sufficiently similar for exact comparison.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1367, 1368.

Dombeyopsis trivialis Lesquereux

(Plate 15, Fig. 4; Plate 16, Figs. 1, 2, 4)

Dombeyopsis trivialis Lesquereux, U. S. Geol. Surv. Terr., 6th Ann. Rept. (1872), 380, 1873; Rept. U. S. Geol. Surv. Terr., vol. 7, 255, pl. 47, fig. 3, 1878; Knowlton, U. S. Geol. Surv. Prof. Paper 130, 163, pl. 13, fig. 3, pl. 14, fig. 3, 1922.

From 31 specimens encountered in the field, 9 well-preserved specimens of this type of leaf were collected for study. The average leaf form, shown here in figures 1 and 4, plate 16, resembles closely the tri-lobed figured specimen of *Dombeyopsis trivialis*, which Lesquereux obtained from the Laramie formation. The resemblance to the actual type specimen at the U. S. National Museum is even closer. The drawing of this specimen is not strictly correct. Actually, the central and lateral lobes are more obtuse and rounded, essentially as in the Medicine Bow specimens.

The specimen shown here in figure 4, plate 15, was at first considered quite distinct. Fortunately, the features of the leaf shown in figure 2 seem to be intermediate in character between this smaller, more elongate leaf and the larger, more rounded leaf of figures 1 and 4. There seems also to be a gradational increase in the size of the lateral lobes, and a widening of the base from the smaller leaf form to the larger. Recognizing the types of variations to be expected in a lobed leaf form of this pattern, it seems justifiable to regard the three specimens as conspecific. In view of the variability shown it is desirable to amplify the original description of this species, which was based on a single fragmentary specimen.

Description (Supplementary)—Leaves palmately trilobed, obovate to cordate in outline, with 1 to 4 inconspicuous to well-developed subsidiary lobes on the outer margins of the lateral lobes; lobation obtuse, rounded; length 6 to 10 cm., width 4 to 8.5 cm., average dimensions apparently about 8 by 7 cm.; base broadly cuneate to cordate; secondary venation tri-palmate, the lateral primaries given off from the top of the petiole, curving slightly upward and entering the lateral primary lobes, secondary veins along midrib remote, wide-angled, curving upward and looping near margins to join secondaries above, 3 to 6 prominent secondaries along marginal sides of lateral primaries, the larger ones often branched and entering lateral lobes, the smaller ones camptodrome; tertiary venation indistinct, the nervilles usually approaching angle of 90° to the primary and secondary veins; texture rather thin.

Dombeyopsis trivialis has thus far been reported only from the Laramie and the Medicine Bow formations. I am not aware of any other late Cretaceous or early Tertiary occurrences of leaves which might possibly be the same.

I do not believe that the affinities of this fossil species are with the existing genus *Dombeya*, as is indicated in the name *Dombeyopsis*. The species of *Dombeya*, in my experience, have invariably more acutely lobed leaves with well-defined acute teeth along their margins. Although I have not seen any modern leaves which are precisely similar to the fossil species, a closer resemblance is seen to the leaves of certain Menispermaceæ: *Cocculus* (*Cebatha*) *diversifolia*, *C. carolinum*, and *Menispermum canadense*, and of the Vitaceæ, particularly *Cissus rhombifolia* of Mexico.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373; Craig, Colorado, Loc. P. 376.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1369, 1370, 1371, 1392.

Family CAPRIFOLIACEÆ

Genus VIBURNUM (Tournefort) Linné

Viburnum marginatum Lesquereux

(Plate 15, Figs. 3, 5; Plate 17, Figs. 4, 5)

Viburnum marginatum Lesquereux, U. S. Geol. Surv. Terr., 6th Ann. Rept. (1872), 395, 1873; U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1873), 382, 401, 1874; idem (1874), 306, 1876; idem (1876), 510, 1878; idem, Bull., vol. 1, 380, 1875; Rept. U. S. Geol. Surv. Terr., vol. 7, 223, pl. 38, figs. 1, 4 only, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, 51, 1888; Knowlton, Geol. Soc. Am. Bull., vol. 8, 145, 1897; Jour. Geol., vol. 19, 361, 370, 371, 1911; Berry, Canada Geol. Surv. Mem. 182, 57, 1935; Brown, U. S. Geol. Surv. Prof. Paper, manuscript, 1937.

Platanus heerii Lesquereux. Ward, U. S. Geol. Surv., 6th Ann. Rept., 552, pl. 40, figs. 8, 9, 1886; idem, Bull. 37, 34, pl. 15, figs. 3, 4, 1887.

Platanus platanoides (Lesquereux) Knowlton (in part), U. S. Geol. Surv. Prof. Paper 101, 323, pl. 95, fig. 4, 1917; idem, Prof. Paper 130, 146, pl. 13, fig. 1, 1922.

Platanus guillelmæ heerii Knowlton, U. S. Geol. Surv. Prof. Paper 101, 323, pl. 96, fig. 5, pl. 97, fig. 1, pl. 98, fig. 2, 1917.

Platanus marginata (Lesquereux) Heer. Knowlton, U. S. Geol. Surv. Prof. Paper 155, 81, pl. 36, figs. 2, 3, 1930.

Platanus aceroides latifolia Knowlton (in part), ibid., 76, pl. 33, fig. 1.

Specimens referable to this species were encountered at 4 of the 6 Medicine Bow localities, although they were abundant only at Locality P. 372, where the field collections contained 241 specimens, of which 20 complete or nearly complete samples were collected for study. The majority of these are of precisely the same size and character as the nearly perfect original type specimen from Black Buttes, Wyoming.[1] Since Lesquereux's report, this species has become known from a number of scattered localities in the late Cretaceous strata of the Rocky Mountain region. Knowlton has very ably discussed the essential distinguishing features and distribution of the species and has described fairly adequately its average leaf form.[2] In view of the better and more abundant material in the Medicine Bow collections it seems highly desirable to make additions and corrections to his description and to attempt to justify the inclusion of the species listed above as conspecific with *Viburnum marginatum*.

Description (Supplementory)—Leaves broadly ovate to obovate, narrowing abruptly above to a blunt obtusely pointed or a short acuminate tip, narrowing more gradually below to an acutely

[1] Lesquereux, Leo, Rept. U. S. Geol. Surv. Terr., vol. 7, pl. 38, fig. 1, 1878.
[2] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 155, 81, 1930.

cuneate base; length 5 to 14 cm., width 5 to 11 cm., average dimensions appear to be about 9 by 8 cm.; petiole thick, long, up to 5 cm.; venation palmate, tri-nerved from the top of the petiole, strong, the midrib straight or slightly zigzag toward the apex, craspedodrome with 4 or 5 pairs of strong, subopposite secondaries, straight, subparallel, diverging from the midrib at an angle of 20° to 30°, more rarely up to 35° but never higher; two lower pairs of secondaries usually branched once or twice, the branches passing to the marginal teeth; lateral primaries diverging at the same angle as the secondaries on the midrib, often slightly longer than secondaries, giving slightly trilobate character to the leaf; each lateral primary with 4 to 6 acute secondary branches on its lower side, the lowest of which bears numerous, usually camptodrome branches, while the upper branches are unbroken, or often once or twice branched and craspedodrome; branches occasionally also developed on upper side of lateral primaries near the margins, usually craspedodrome; tertiary venation strong, the nervilles both broken and percurrent; margin entire below to near the middle of the leaf, becoming denticulate above, the teeth small, usually acute, occasionally slightly obtuse; texture firm.

Lesquereux originally included in *Viburnum marginatum* several smaller leaves of quite different character,[1] which both Knowlton and Berry later agreed should be separated into a new species. The evidence from the Medicine Bow collections substantiates separation, since the smaller specimens of *V. marginatum* (see plate 15, figure 3) are consistently of the same character as the larger specimens. It is, of course, possible that this species may have had two entirely different leaf forms among the smaller leaves. Whether or not this is probable must remain a matter of opinion until branches bearing both kinds of smaller leaves be discovered.

From the same locality from which *V. marginatum* was described Lesquereux obtained several larger specimens of what he called *V. platanoides*. These he distinguished from *V. marginatum* by the "less numerous, more open, lateral veins, whose branches are more curved in passing up to the borders, and especially by the enlarged truncate or subtruncate base of the leaves." [2] I was at first inclined to regard the leaves of this type as large forms of *V. marginatum*, but failed to find a single form among the hundreds of Medicine Bow specimens which possessed the essential characters of *V. platanoides*. Moreover, the large specimens in the collections maintained consistently the diagnostic characters of *V. marginatum*. It seems evident, therefore, that these two species are distinct, as Knowlton has previously concluded.[3]

The abundant material of *V. marginatum* now available makes it possible to revise the status of several late Cretaceous specimens referred to various species of *Platanus*. The specimens which Ward obtained from the type locality of *Viburnum marginatum* and which he referred to the Dakota species *Platanus heerii* are clearly referable to the former species in every respect. The Raton and Laramie specimens referred to *P. platanoides* by Knowlton are easily distinguished from that species by their cuneate bases, shape, and venation. I am also convinced that the Raton specimens referred to *P. guillelmæ heerii* and the Denver specimen referred to *P. aceroides latifolia* are indistinguishable from the larger specimens of *Viburnum marginatum*, which are often slightly trilobate in shape.

The previous and present record of *V. marginatum* indicates that it is an extremely widespread, abundant, and easily recognizable species, which is limited stratigraphically to deposits of latest Cretaceous age. It is unknown from the extensive floras of indisputable Paleocene or later age of the Rocky Mountain region. It may possibly be present in the Paleocene of Texas.[4] The exact formation here is in doubt, however, and the specimens (= *Platanus aceroides latifolia*) have not been figured, making the occurrence of doubtful value.

The generic status of *Viburnum marginatum* has suffered considerable vacillation between the genera *Viburnum* and *Platanus*. Lesquereux originally referred the species to *Viburnum* on the basis of comparison with the modern *V. pubescens* Pursh, *V. dentatum* Linné, and *V. lantanoides* Michx. Heer subsequently discovered leaves which he considered conspecific with *V. marginatum* in the Tertiary (Eocene?) of Unartok, Greenland, and referred the species to *Platanus*. Heer's specimens are undeniably platanoid and are closely associated with typical platanoid fruits, but the leaves are clearly different in shape and basal characters from Lesquereux's specimens, and, as Hollick has pointed out, "should be regarded not only as specifically but also as generically

[1] Lesquereux, Leo, Rept. U. S. Geol. Surv. Terr., vol. 7, pl. 37, fig. 11, pl. 38, figs. 2, 3, 5, 1878.
[2] Lesquereux, Leo, U. S. Geol. and Geog. Surv. Terr., Ann. Rept. (1874), 314, 1876.
[3] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 146, 1922.
[4] Berry, E. W., U. S. Geol. Surv. Prof. Paper 91, 13, 1916.

distinct."[1] Knowlton followed Heer in referring the species to *Platanus*, but in more recent reports both Berry[2] and Brown[3] have reverted to the original reference to *Viburnum*, in which I concur. In comparisons with modern herbarium material at The New York Botanical Garden, I have seen no leaves of *Platanus* comparable to the combination of characters observed in the leaves of *Viburnum marginatum*. These bear a close resemblance to several species of *Viburnum*, however, such as the species mentioned by Lesquereux, and more particularly *V. opulus* and *V. pauciflorum* of North America and *V. sargentii* Koehn of China.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Loc. P. 376.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1372, 1373, 1374, 1375.

Viburnum montanum Knowlton

(Plate 17, Fig. 2)

Viburnum montanum Knowlton, U. S. Geol. Surv. Bull. 163, 73, pl. 19, figs. 1, 2, 1900; idem, Prof. Paper 101, 276, pl. 52, fig. 2, 1917.

Viburnum? problematicum Knowlton, U. S. Geol. Surv. Bull. 163, 71, pl. 19, fig. 4, 1900; idem, Prof. Paper 101, 276, pl. 49, fig. 9, 1917.

The collections contain only 4 well-preserved specimens of this form, of which the best is here figured. This is difficult to distinguish from the type and figured specimens of the two species mentioned above, particularly those from the Vermejo formation.

It is possible, as Knowlton has pointed out, that these specimens are variants of *Viburnum marginatum* Lesquereux. In the absence of gradational variants between the narrow elliptic leaves of *V. montanum* and the typical smaller leaves of *V. marginatum* shown on plate 15, figure 3, it seems necessary to maintain the former as distinct. I suspect that a larger suite of specimens of this species might bring out a close resemblance and possibly identity to the leaves referred to *V. contortum*,[4] which is known from the Raton and Black Buttes floras, and to *V. speciosum* from the Raton.[5]

The previously recorded occurrences of *V. montanum* are limited to the Mesaverde and Vermejo formations of Colorado and to the undifferentiated Montana group of Utah.

I can suggest no better generic reference for this species than *Viburnum*.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; Elk Mountain road, Wyoming, Loc. P. 374.

Collection—U. C. Mus. Pal., Plesiotype No. 1376.

DICOTYLEDONÆ—POSITION UNCERTAIN

Phyllites eraigensis Dorf, n. sp.

(Plate 18, Fig. 3)

There are 4 well-preserved specimens of a very distinctive type of leaf from Locality P. 375. I have been unable to find any fossil or living species with which a comparison could be made. It seems desirable, nevertheless, to describe and figure the species for future reference.

Description—Leaves wide-elliptic, with the base broadly cuneate and the tip acutely rounded; length ranging from 8 to 13 cm., width from 4 to 8 cm., widest at the middle; petiole very stout, short, wider than the midrib; midrib very thick below, gradually thinning toward the apex; secondary venation indistinct, pinnate, 12 to 18 pairs of secondaries mainly decurrent along the midrib, diverging at an angle of about 40° near the base and a somewhat greater angle near the apex; secondaries branched irregularly and acutely, curving only slightly upward, becoming indistinct near the margins; tertiary venation obsolete; margin entire; texture coriaceous.

In both shape and venation the fossil specimens approximate the leaves of several living species of the genera *Drimys* and *Illicium* of the Magnoliaceæ. The resemblance to *Illicium floridanum* Ellis is striking in all characters except width and expanded petiole.

[1] Hollick, A., U. S. Geol. Surv. Prof. Paper 182, 166, 1936.
[2] Berry, E. W., Canada Geol. Surv. Mem. 182, 57, 1935.
[3] Brown, R. W., U. S. Geol. Surv. Prof. Paper, manuscript, 1937.
[4] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 101, 346, pl. 108, fig. 3, 1917.
[5] Knowlton, F. H., ibid., 347, pl. 111, figs. 1–5.

Occurrence—Craig, Colorado, Loc. P. 375.
Collection—U. C. Mus. Pal., Type No. 1377.

Phyllites wilderi Dorf, n. sp.

(Plate 18, Fig. 4)

The single specimen figured is the only one of this kind in the collections. I have been unable to find any figured fossil forms with which a comparison was justified. The specimen is complete enough, however, to warrant description and figure for possible future reference.

Description—Leaf oval-obovate, with asymmetrical, acutely cuneate base, and short, bluntly pointed tip; length approximately 11 cm., width about 4.5 cm. at the widest portion just above the middle; midrib heavy, straight; about 8 pairs of thin secondaries, mainly opposite or subopposite, rather equally and distantly spaced, branching from the midrib at an angle of 50° to 60°, and converging slightly toward the margin where they form inconspicuous loops with the secondaries above; margin entire; texture firm.

The species is named for Mr. Beverly Wilder, who assisted in the collection of the material.

Definite generic allocation of this specimen cannot be made until a larger suite of better material can be obtained.

Occurrence—Elk Mountain road, Wyoming, Loc. P. 374.
Collection—U. C. Mus. Pal., Type No. 1378.

Phyllites conwayi Dorf, n. sp.

(Plate 18, Fig. 2)

The figured specimen is the only one of this type of leaf in the collections. It is so nearly complete, however, that it seems desirable to record its presence in the Medicine Bow flora. No comparable fossil forms have been recorded, to my knowledge.

Description—Leaf obovate, narrowed rather abruptly to a slightly acuminate, rounded tip and more gradually to an apparently broadly cuneate base; length about 11 cm., width 7.5 cm.; midrib stout and straight; 6 to 7 pairs of prominent secondaries, occasionally decurrent, leaving the midrib at angles of 40° to 60°, arching abruptly upward well within the margin to join secondaries above or their lower branches in wide loops; tertiary veins fairly prominent, widely spaced, mainly percurrent, occasionally parallel to secondaries along the midrib; margin entire; texture fairly thin.

I have no suggestions regarding a generic reference for this specimen.

Occurrence—Corson Ranch, Wyoming, Loc. P. 371.
Collection—U. C. Mus. Pal., Type No. 1379.

Phyllites colubrinoides Dorf, n. sp.

(Plate 19, Figs. 4, 5)

There are 8 specimens from 2 localities which at first seem comparable to the leaves referred to *Trochodendroides nebrascensis*. Closer scrutiny, however, reveals a number of differences which are so constant that I am convinced that these leaves belong to a different species, if not also a different genus. The main points of distinction appear to be the thick coriaceous texture, the relatively large, evenly spaced teeth, the turned-down petiole, the narrowly cuneate base and the inward-looping prominent secondaries and tertiaries in the leaves here referred to *Phyllites colubrinoides*.

Description—Leaves wide-lanceolate to elliptic, gradually narrowed to an acute apex and a narrowly cuneate base; length 3 to 6.5 cm., width 2 to 3.3 cm.; petiole turned abruptly downward, not well preserved; prominently 3 pli-nerved from the top of the petiole, the midrib and lateral primaries of almost equal strength; lateral primaries leaving the midrib at 30° angle or less, curving abruptly upward, paralleling midrib to near the apex where they fork into two veins, one of which enters a marginal tooth, the other looping inward to join the upper secondaries; one pair of prominent secondaries diverging acutely from above the middle of the midrib, running subparallel to the midrib, forking into the marginal teeth, and ultimately looping inward to join the midrib near the apex; 5 or 6 prominent secondaries given off from the marginal side of the lateral primaries, looping distinctly upward to join the ones above, and giving off less prominent tertiary veins into

the marginal teeth; tertiary veins between midrib and lateral primaries distinct, mainly forming upward convex arches; margin serrate, the teeth prominent, evenly spaced and upward-pointing; texture very coriaceous.

The only described fossil form which I have found comparable to this species is *Zizyphus meekii* Lesquereux from the Hanna formation of Carbon, Wyoming.[1] There are easily recognized differences, however, in shape, texture, marginal teeth, and venation, which were more apparent in the comparison with the actual type specimens than with Lesquereux's figures.

The specific name given to this species implies a close resemblance to the leaves of *Colubrina* (Rhamnaceæ), particularly *C. asiatica* Brongn. and *C. pubescens* Kurz. The specimens are also comparable in general to leaves of *Zizyphus* and *Paliurus* of the same family.

Occurrence—Corson Ranch, Wyoming, Locs. P. 371, P. 372.

Collection—U. C. Mus. Pal., Type No. 1380, Paratype No. 1381.

Phyllites sp.

(Plate 18, Fig. 1)

There are several fragments and the fairly complete specimen figured which apparently are quite distinct from any other leaf form in the collections. I have not been able to identify this type either generically or specifically. The general shape and character of the venation suggest a reference to the genus *Styrax*. The specimen is included mainly for future reference.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372.

Collection—U. C. Mus. Pal., No. 1382.

POSITION UNCERTAIN

Genus PALÆOASTER Knowlton

Palæoaster inquirenda Knowlton

(Plate 19, Figs. 3, 6)

Palæoaster inquirenda Knowlton, U. S. Geol. Surv. Prof. Paper 101, 278, pl. 49, figs. 5, 6, 1917.
Palæoaster? similis Knowlton, U. S. Geol. Surv. Prof. Paper 130, 168, pl. 24, figs. 10, 11, 1922.

The 2 specimens figured are the only representatives of this unique species in the collections. Each consists of a whorl of segments or "leaves," apparently eight or ten in number, joined at the base and free at the apex, to form a spheroidal mass. Each segment is traversed longitudinally by a deep median furrow or rib, and perpendicularly from the midrib to the margin by closely spaced, subparallel, wavy lines. These are precisely the diagnostic features of *Palæoaster inquirenda* from the Vermejo and Raton formations. The same characters are present in the Laramie specimens of *P. ? similis*, which Knowlton maintained as distinct because of its fewer segments and its attachment to a stalk. The presence of 4 segments in the exposed half of the Laramie specimen would seem to me to imply the existence of an approximately equal number in the unexposed half, bringing the total number of segments to 8 or more, rather than 5 or 6 as Knowlton reported. The attachment to a stalk seems equally fortuitous, and of doubtful taxonomic significance. I have therefore regarded the 2 species as synonymous.

I hesitate to separate either of these species from *Sterculiocarpus colorodensis* Berry from the Dawson (?) formation.[2] This species differs mainly in the presence of longitudinal ridges rather than furrows along the median line of the segments. I am inclined toward the view expressed by Berry that remains of this type are seed capsules rather than of foliar nature. I have been unable to find any modern forms with which these specimens might be compared.

During the past year I obtained an excellent limonitized specimen of this same unusual seed capsule (?) from the Lance formation near Glendive, Montana. The specimen was collected and sent to Professor G. L. Jepsen of Princeton University by Mr. O. T. Lewis of Helena, Montana.

Occurrence—North of Walcott, Wyoming, Loc. P. 373.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1383, 1384.

[1] Lesquereux, Leo, Rept. U. S. Geol. Surv. Terr., vol. 7, 275, pl. 51, figs. 10–14, 1878.
[2] Berry, E. W., Washington Acad. Sci. Jour., vol. 22, 119, figs. 1, 2, 1932.

Carpites walcotti Dorf, n. sp.

(Plate 19, Figs. 1, 2)

There are 6 nearly perfect specimens from 3 localities which are obviously elongate seeds. Comparable fossil seeds are apparently rare. They bear a superficial resemblance to the seeds referred to *Pisonia fructifera* Berry from the Wilcox flora [1] but are clearly not the same species.

Description—Seeds narrowly elliptic in flattened view, abruptly truncate at the apex and gradually narrowed below to an acutely cuneate base; length rather consistently 1.5 cm., width 4 to 5 mm., peduncle stout, long, up to 1.8 cm., surface ribbed, the costæ widely spaced and numbering 3 or 4; apex invested with thin, short projections, the outer ones longer than the inner ones.

These seeds are unusually complete and should be easily identified generically. I have as yet found no modern seeds, however, which I could consider strictly comparable. Those of *Nyssa aquatica* Linné, which are borne singly on long peduncles, are often of precisely the same character,[2] though they may become larger and more rounded.

Occurrence—North of Walcott, Wyoming, Loc. P. 373; Elk Mountain road, Wyoming, Loc. P. 374; Craig, Colorado, Loc. P. 375.

Collection—U. C. Mus. Pal., Cotypes Nos. 1385, 1386.

Carpites glumæformis Lesquereux

(Plate 14, Figs. 3, 4)

Carpites glumæformis Lesquereux, Rept. U. S. Geol. Surv. Terr., vol. 7, 304, pl. 35, fig. 4d, pl. 60, figs. 14–17, 1878.

Seeds (?) of this type are rather abundant in the collections, being represented by more than a dozen specimens. They are essentially like the type and figured specimens of this species, which is common in the Black Buttes flora. No other fossil occurrences are known. The exact nature of these specimens has not been determined.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372; north of Walcott, Wyoming, Loc. P. 373.

Collection—U. C. Mus. Pal., Plesiotypes Nos. 1387, 1388.

Phyllites trillioides Dorf, n. sp.

(Plate 17, Fig. 3)

There are but 2 incomplete specimens of this type in the collections. The general outline, venation, and heart-shaped base are typical of the leaves usually referred to *Smilax*. In modern leaves of *Smilax*, however, I have never seen forking primary veins such as are present in these fossil specimens. The leaves of *Trillium*, on the other hand, are almost always characterized by forking primaries (cf. *T. cernuum* Linné).[3] In the absence of more complete material, however, it is impossible to make a definite generic reference.

These specimens resemble both *Smilax? inquirenda* Knowlton from the Laramie formation [4] and *S. carbonensis* Cockerell from the Hanna formation.[5] There are enough characters preserved, however, to indicate that they are not conspecific with either.

Occurrence—Craig, Colorado, Loc. P. 375.

Collection—U. C. Mus. Pal., Type No. 1389.

Bracts (?)

(Plate 14, Fig. 2)

There are several well-defined specimens which may be seed bracts or bud scales. Although their systematic position is problematical, they are sufficiently well preserved to be recorded for possible future reference.

Occurrence—Corson Ranch, Wyoming, Loc. P. 372.

Collection—U. C. Mus. Pal., No. 1390.

[1] Berry, E. W., U. S. Geol. Surv. Prof. Paper 156, 68, pl. 11, figs. 5, 6, 1930.
[2] See sheet No. 201 (= *N. uniflora* Wang.) at Princeton University herbarium.
[3] See sheet No. 51, Princeton University herbarium.
[4] Knowlton, F. H., U. S. Geol. Surv. Prof. Paper 130, 118, pl. 4, fig. 5, 1922.
[5] Lesquereux, Leo, Rept. U. S. Geol. Surv. Terr., vol. 7, 94, pl. 9, fig. 5 (= *Smilax grandifolia* Unger), 1878.

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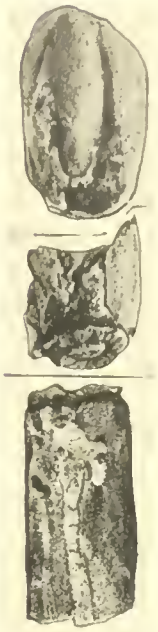
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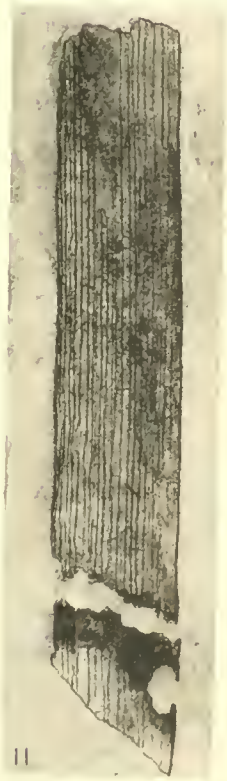
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PLATE 2

FIG. 1—*Sequoia? acuminata* Lesquereux. Plesiotype. U.C. Mus. Palæobot., No. 1295 . . . . . .

FIGS. 2, 3—*Palmocarpon? subcylindricum* Lesquereux. Plesiotypes. U.C. Mus. Palæobot., Nos. 1304, 1303 . . . . . .

FIG. 4—*Zingiberites dubius* Lesquereux. Plesiotype. U.C. Mus. Palæobot., No. 1306 . . . . . .

FIG. 5—*Canna* cf. *C.? magnifolia* Knowlton. U.C. Mus. Palæobot., No. 1305

FIG. 6—*Sabalites eocenica* (Lesquereux) Dorf. Plesiotype. U.C. Mus. Palæobot., No. 1301 . . . . . .

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PLATE 3

FIG. 1—*Juglans leconteana* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 1310 . . . . . .

FIG. 2—*Sabalites montana* (Knowlton) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 1300 . . . . . .

FIG. 3—*Sabalites eocenica* (Lesquereux) Dorf. Plesiotype. U. C. Mus. Palæobot., No. 1302 . . . . . .

FIG. 4—*Pandanites corsoni* Dorf. Holotype. U. C. Mus. Palæobot., No. 1298

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PLATE 4

FIGS. 1, 2, 3—*Myrica torreyi* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1309, 1307, 1308 . . . . . .

FIG. 4—*Juglans newberryi* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 1311 . . . . . .

FIG. 5—*Juglans leconteana* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 1393 . . . . . .

FIG. 6—*Juglans praerugosa* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 1312 . . . . . .

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PLATE 5

FIGS. 1, 2, 6—*Dryophyllum subfalcatum* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1313, 1315, 1314 . . . . . .

FIGS. 3, 4, 5, 7—*Ficus planicostata* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1320, 1319, 1391, 1321 . . . . . .

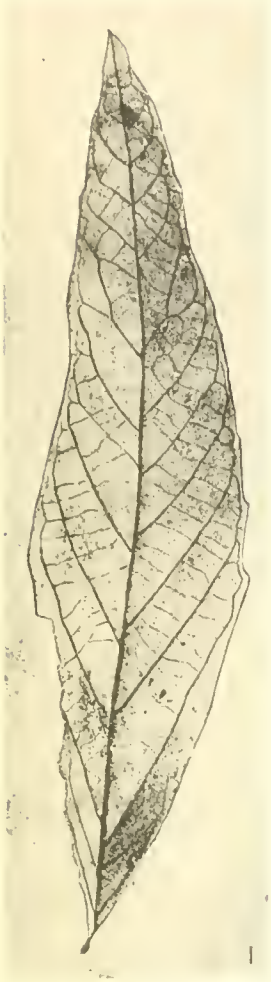
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PLATE 6

FIGS. 1, 4—*Ficus trinervis* Knowlton. Plesiotypes. U. C. Mus. Palæobot., Nos. 1324, 1323 . . . . . .

FIG. 2—*Ficus tesselata* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 1326 . . . . . .

FIGS. 3, 5, 7—*Quercus viburnifolia* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1316, 1317 . . . . . .

FIG. 6—*Ficus coloradensis* Cockerell. Plesiotype. U. C. Mus. Palæobot., No. 1327 . . . . . .

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PLATE 7

FIG. 1—*Ficus cowanensis* Knowlton. U. C. Mus. Palæobot., No. 1328 . . .

FIG. 2—*Ficus cockerelli* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 1322 . . . . . .

FIG. 3—*Ficus crossii* Ward. Plesiotype. U. C. Mus. Palæobot., No. 1325 . .

FIG. 4—*Laurus socialis* Lesquereux? Plesiotype? U. C. Mus. Palæobot., No. 1335 . . . . . .

FIG. 5—*Laurophyllum meeki* Dorf. Plesiotype. U. C. Mus. Palæobot., No. 1334 . . . . . .

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PLATE 8

FIG. 1—*Credneria protophylloides* Knowlton. X ¾. Plesiotype. U. C. Mus. Palæobot., No. 1329 . . . . . .

PLATE 9

FIG. 1—*Cinnamomum linifolium* Knowlton. Plesiotype. U. S. Nat. Mus. Coll., No. 1331 . . . . . .

FIG. 2—*Pisonia? racemosa* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 1330 . . . . . .

FIGS. 3, 4—*Cinnamomum affine* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1332, 1333 . . . . . .

FIG. 5—*Magnoliophyllum cordatum* Dorf. Cotype. U. C. Mus. Palæobot., No. 1345 . . . . . .

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PLATE 10

FIG. 1—*Magnoliophyllum cordatum* Dorf. Cotype. U. C. Mus. Palæobot., No. 1344 . . . . . .

FIG. 2—*Magnolia lakesii* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 1340 . . . . . .

FIG. 3—*Magnolia dakotana* Berry. Plesiotype. U. C. Mus. Palæobot., No. 1341 . . . . . .

FIG. 4—*Magnolia nervosa* (Knowlton) Brown. Plesiotype. U. C. Mus. Palæobot., No. 1342 . . . . . .

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PLATE 11

FIGS. 1, 4, 6, 7—*Trochodendroides nebrascensis* (Newberry) Dorf. Plesiotypes. U. C. Mus. Palæobot., Nos. 1337, 1336, 1339, 1338 . . .

FIGS. 2, 3, 5—*Leguminosites arachioides minor* Berry. Plesiotypes. U. C. Mus. Palæobot., Nos. 1348, 1346, 1347 . . . . . .

FIG. 8—*Magnolia pulchra* Ward. Plesiotype. U. C. Mus. Palæobot., No. 1343 . . . . . .

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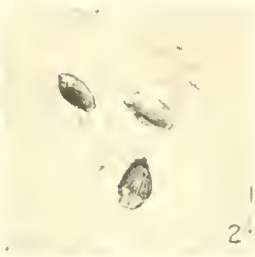
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PLATE 12

FIGS. 1, 2, 3—*Celastrus taurinensis* Ward. Plesiotypes. U. C. Mus. Palæobot., Nos. 1350, 1352, 1351 . . . . . .

FIGS. 4, 5—*Rhamnus salicifolius* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1353, 1354 . . . . . .

FIG. 6—*Zizyphus hendersoni* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 1358 . . . . . .

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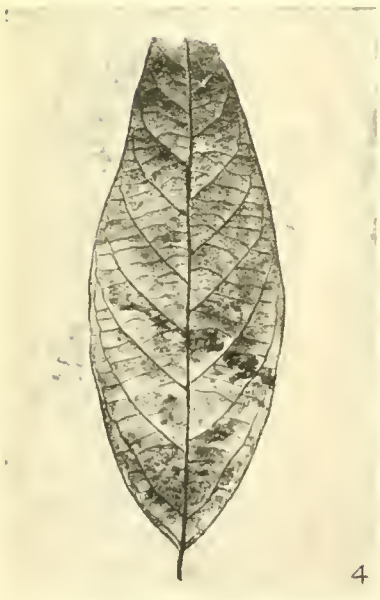
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PLATE 13

FIGS. 1, 5, 6—*Grewiopsis saportana* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1364, 1363, 1365 . . . . . .

FIGS. 2, 3—*Cissites lobatus* Dorf. U. C. Mus. Palæobot., Type No. 1359; Paratype No. 1360 . . . . . .

FIG. 4—*Rhamnus salicifolius* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 1355 . . . . . .

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PLATE 14

FIG. 1—*Apeibopsis ? laramiensis* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 1362 . . . . . .

FIG. 2—Bracts (?) U. C. Mus. Palæobot., No. 1390 . . . . . .

FIGS. 3, 4—*Carpites glumaeformis* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1387, 1388. . . . . .

FIGS. 5, 6—*Rhamnus cleburni* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., No. 1357 . . . . . .

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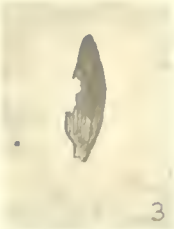
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PLATE 15

FIGS. 1, 2—*Dombeyopsis obtusa* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1367, 1368 . . . . . .

FIGS. 3, 5—*Viburnum marginatum* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1373, 1372 . . . . . .

FIG. 4—*Dombeyopsis trivialis* Lesquereux. Plesiotype. U. C. Mus. Palæobot., No. 1369 . . . . . .

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PLATE 16

FIGS. 1, 2, 4—*Dombeyopsis trivialis* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1370, 1371, 1392 . . . . . .

FIG. 3—*Cornophyllum wardii* Dorf. Type. U. C. Mus. Palæobot., No. 1366

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PLATE 17

FIG. 1—*Vitis stantoni* (Knowlton) Brown. Plesiotype. U. C. Mus. Palæobot., No. 1361 . . . . . .

FIG. 2—*Viburnum montanum* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 1376 . . . . . .

FIG. 3—*Phyllites trillioides* Dorf. Type. U. C. Mus. Palæobot., No. 1389 . .

FIGS. 4, 5—*Viburnum marginatum* Lesquereux. Plesiotypes. U. C. Mus. Palæobot., Nos. 1374, 1375 . . . . . .

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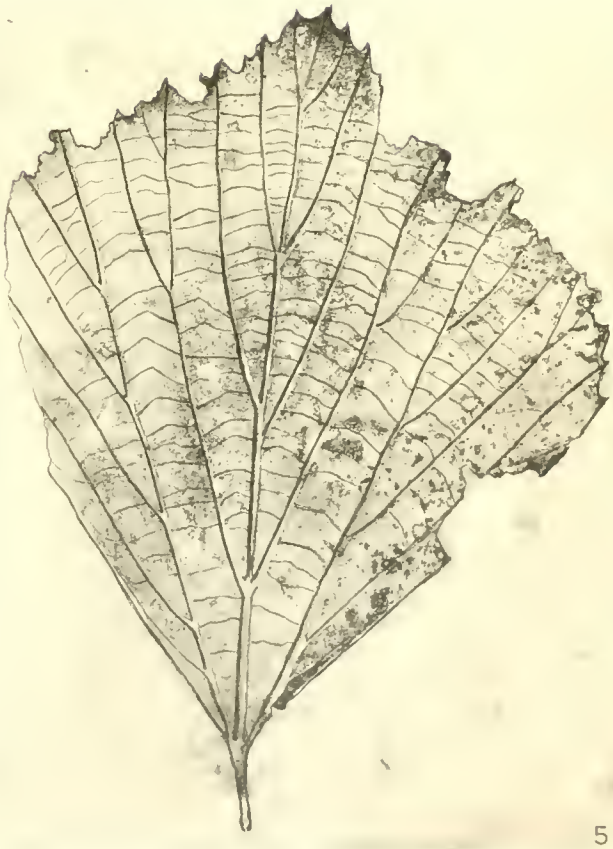
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PLATE 18

FIG. 1—*Phyllites sp.* U. C. Mus. Palæobot., No. 1382

FIG. 2—*Phyllites conwayi* Dorf. Type. U. C. Mus. Palæobot., No. 1379

FIG. 3—*Phyllites craigensis* Dorf. Type. U. C. Mus. Palæobot., No. 1377

FIG. 4—*Phyllites wilderi* Dorf. Type. U. C. Mus. Palæobot., No. 1378

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PLATE 19

FIGS. 1, 2—*Carpites walcotti* Dorf. Cotypes. U. C. Mus. Palæobot., Nos. 1386, 1385 . . . . . .

FIGS. 3, 6—*Palaeoaster inquirenda* Knowlton. Plesiotypes. U. C. Mus. Palæobot., Nos. 1384, 1383 . . . . . .

FIGS. 4, 5—*Phyllites colubrinoides* Dorf. U. C. Mus. Palæobot., Type No. 1380; Paratype No. 1381 . . . . . .

FIG. 7—*Pistacia eriensis* Knowlton. Plesiotype. U. C. Mus. Palæobot., No. 1349 . . . . . .

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